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ABBREVIATIONS. — D. = Discussion; I. = Illustrated.

Names of authors are printed in *italics*.

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LOSS OF WATER BY SEEPAGE AND EVAPORATION, FERRE CANAL.

BY W. B. GREGORY, MEMBER LOUISIANA ENGINEERING SOCIETY.

[Read before the Society, April 8, 1912.]

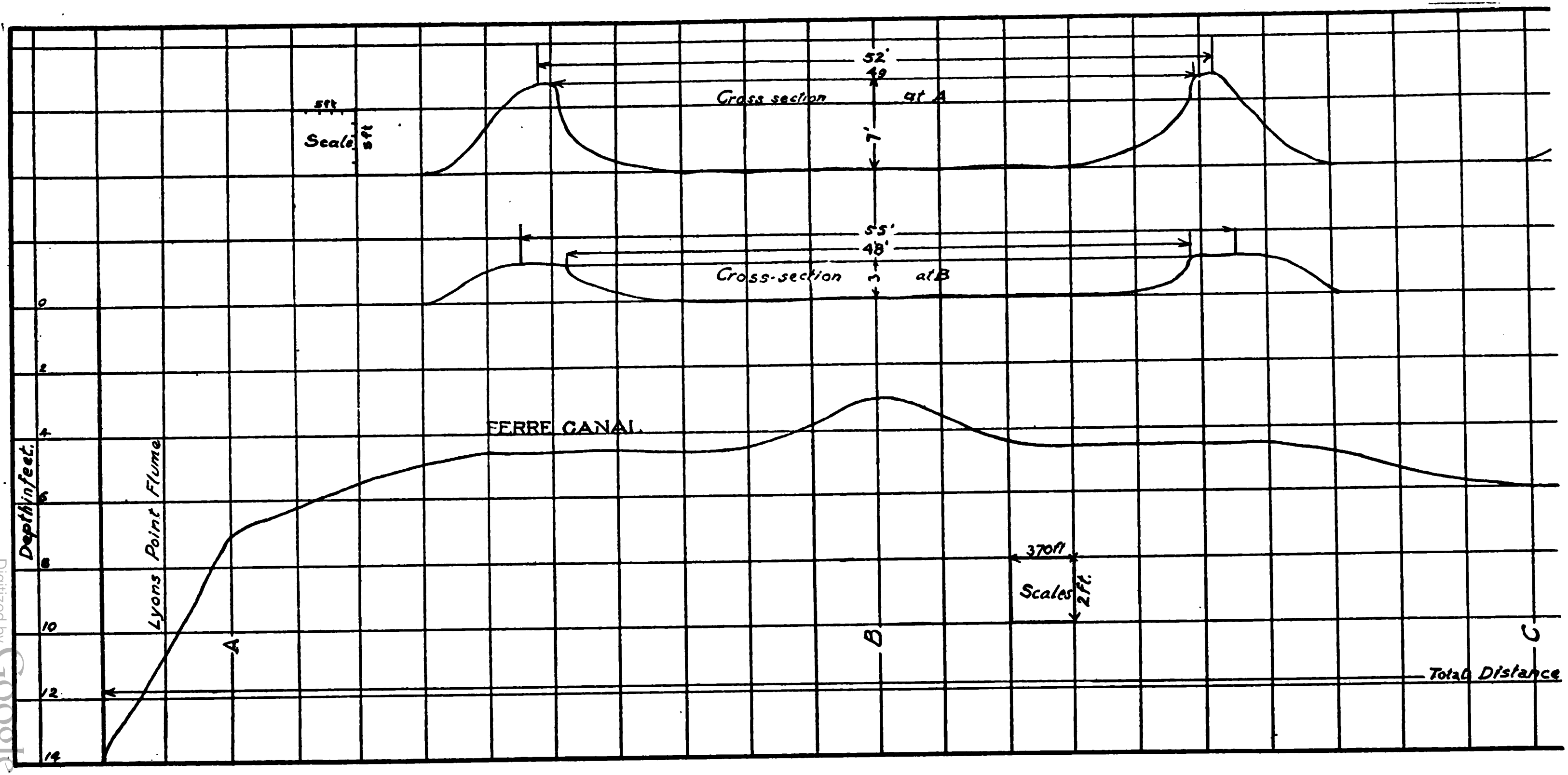
As measurements of seepage losses from canals had never been made in the rice country, the opportunity for this work was welcomed during the pumping season of 1911.

The Ferre Canal is a typical rice irrigation canal, furnishing water to approximately 6 500 acres of rice.

The surface soil through which the canal passes is Acadia silt loam, according to the soil survey of the Bureau of Soils, United States Department of Agriculture. The subsoil is in part a very sticky yellow clay. Where the embankments are high, a considerable amount of the subsoil was used in their construction. The accompanying plate shows the distances from the tops of levees to the bottom of canal at intervals of 740 ft. between the two flumes where the flow of water was measured. Four typical sections are also shown. Water is carried very high in this canal, usually within 3 or 4 in. of the top.

Two current meters were used. One was a Gurley tail meter, the property of the Tulane University of Louisiana, and the other, a rod meter No. 112, the property of Irrigation Investigations, United States Department of Agriculture. After the observations were completed, both meters were carefully rated at the filtration plant of the New Orleans Water Works.

An attempt was made to determine seepage and evaporation losses on the canal early in July, but heavy and incessant rains were the cause of postponement of the work to a later date.



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49
Cross section at A
7'
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Scale
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Cross-section at B
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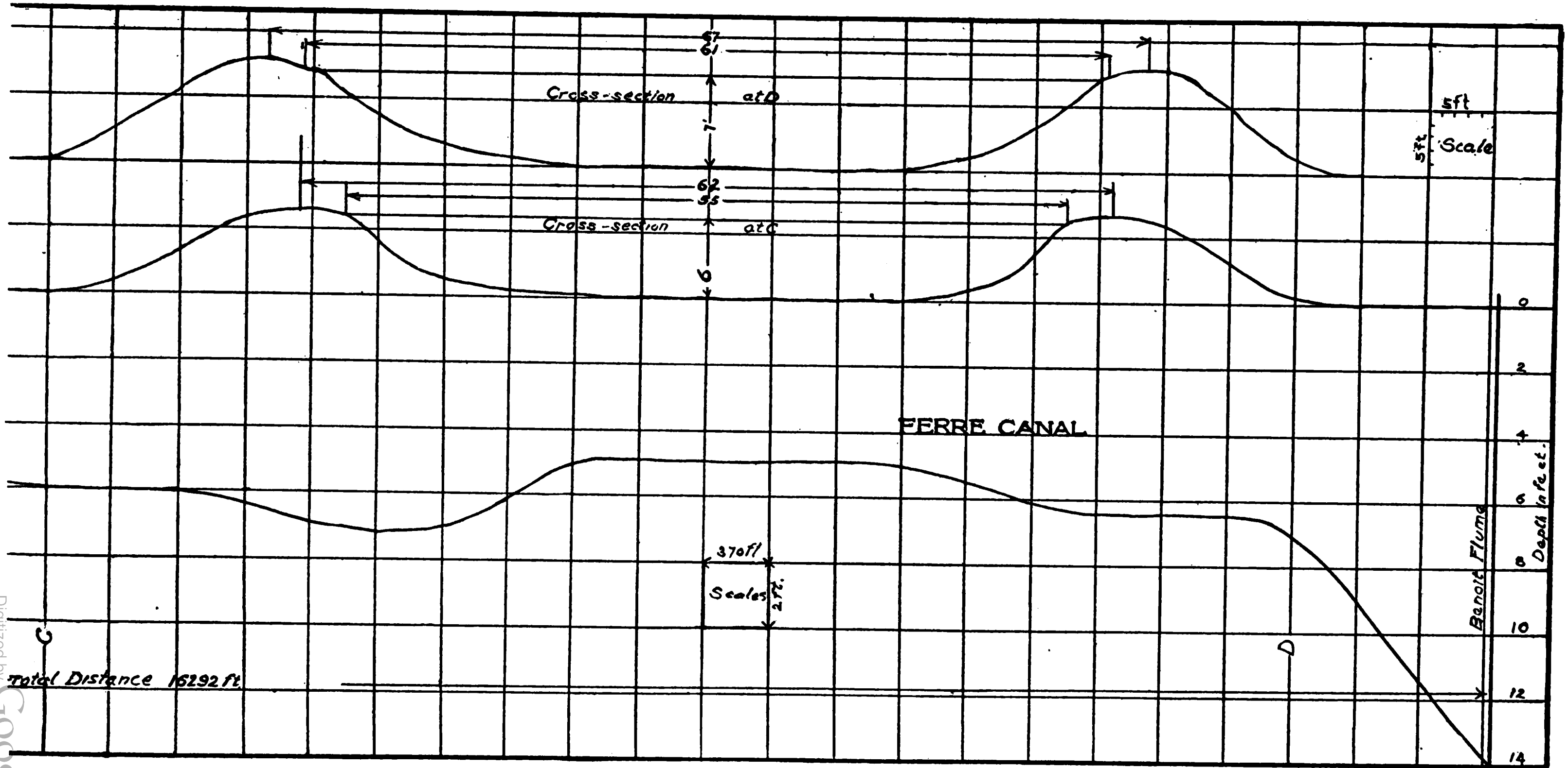
Depth in feet.
FERRE CANAL.
Lyons Point Flume
A
B
C
370ft
Scales
2ft.
Total Distance


FERRE CANAL
Cross-section at D
Cross-section at C
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Total Distance 16292 ft
Benoit Flume
Depth in feet.
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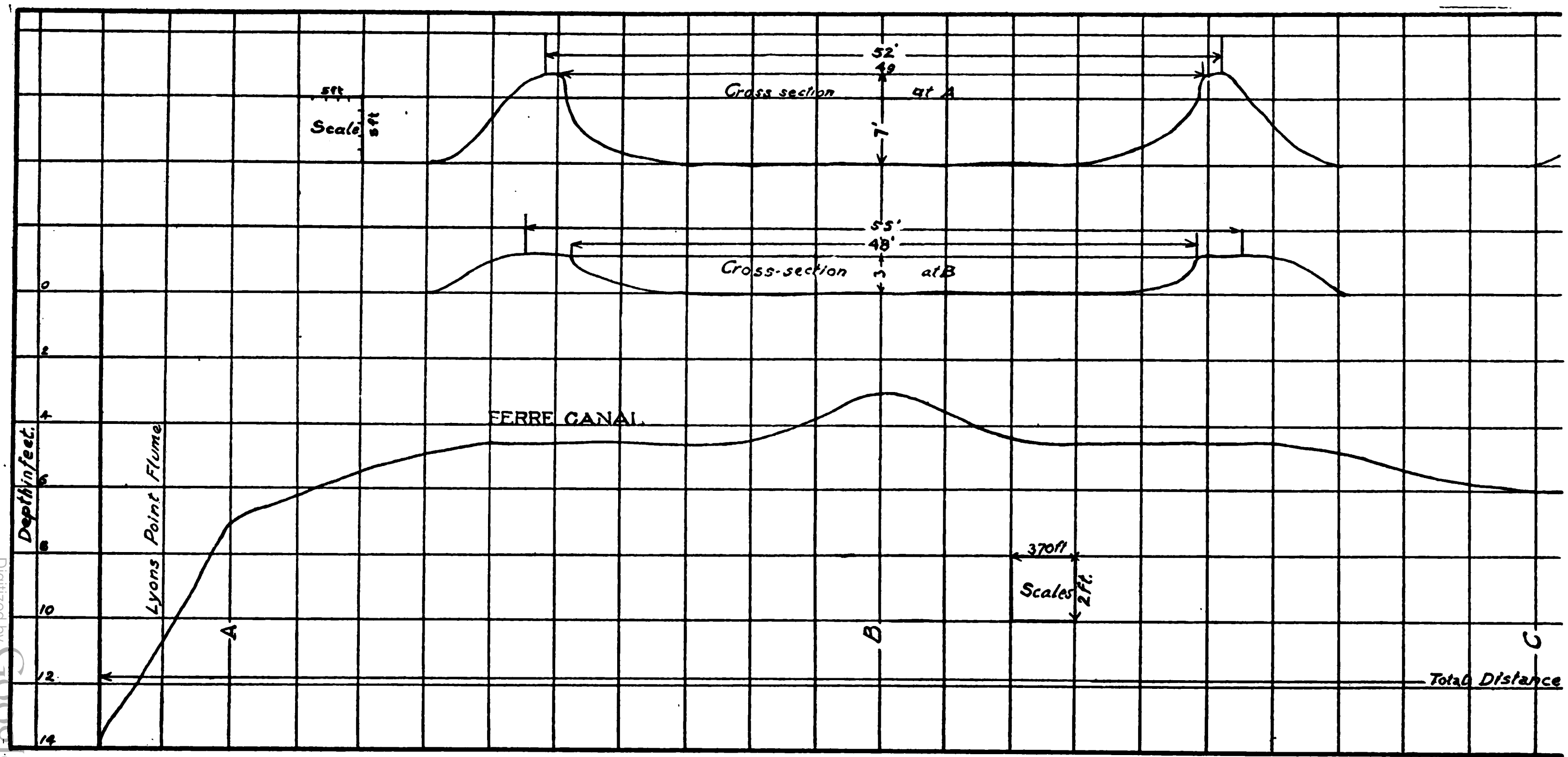

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Depth in feet.
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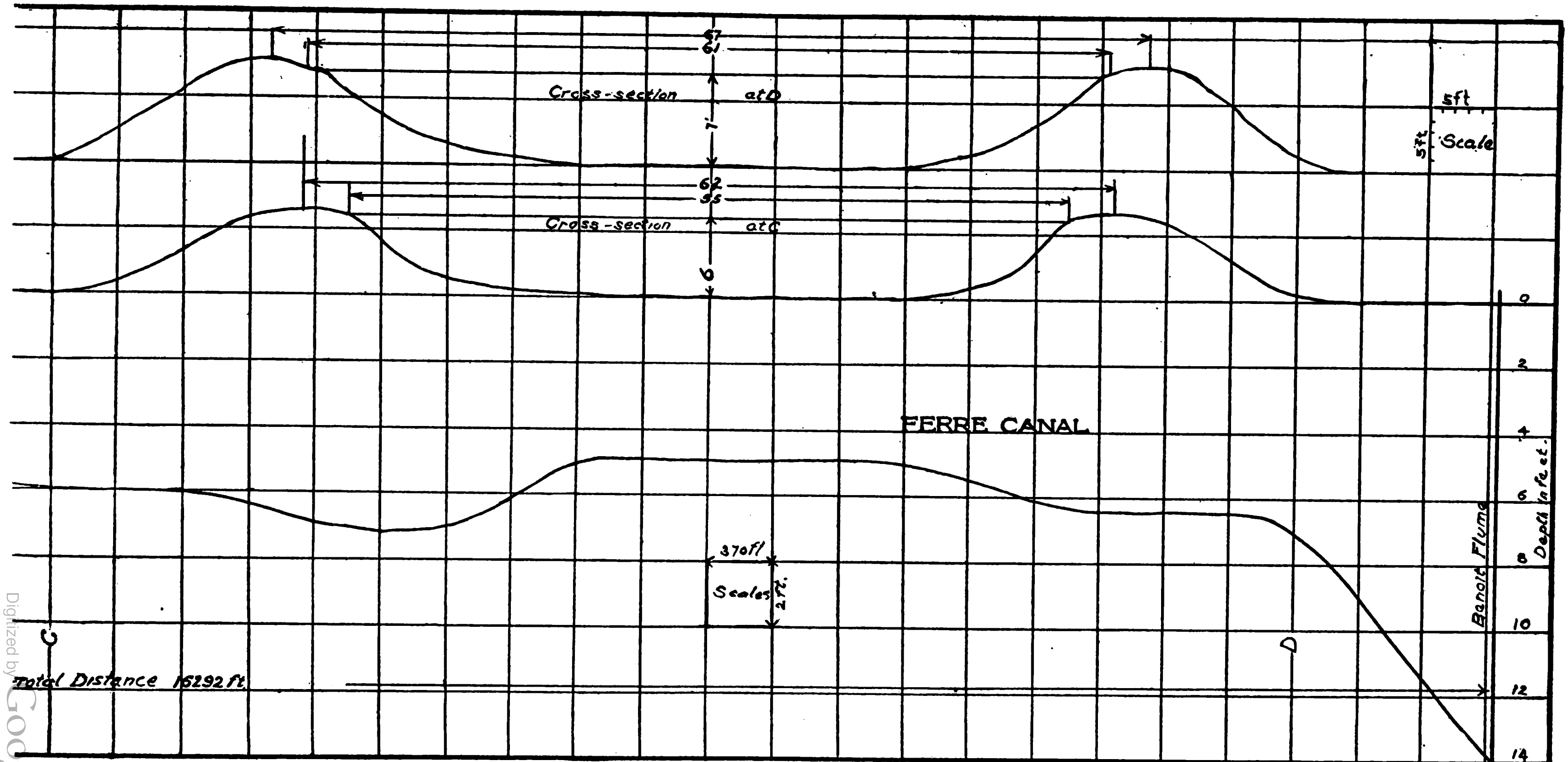

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Depth in feet.
0
2
4
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8
10
12
14
C
D
Total Distance 16292 ft.

The determination was finally made on August 7, 1911. The method was as follows:

One observer was located at a flume about a half mile from the pumping plant, which is on Bayou Que de Tortue. This flume is known as the Benoit flume. Another flume of similar section is located 16 292 ft. or 3.08 miles further down the canal,

SEEPAGE EXPERIMENT, FERRE CANAL. MORSE, LA., Aug. 7, 1911.

V = Velocity parallel to axis of flume.
Vc = Velocity at right angles to axis of flume.
Vr = Resultant velocity as determined by current meter.

BENOIT FLUME. Width, 17.89 ft. Observer, W. B. G.; Rod Meter No. 112.

Hour.		Time. M. Sec.	Secs.	Revs.	Revs. per Sec.	*Vr.*	*Vc.*	Mean Depth. Ft.	*V.*	*Q.*
A.M.	9:00	4–34.7	274.7	136	.495	1.310	.130	3.404		
	9:20	4–31.3	271.3	133	.490	1.300	.132	3.397		
	9:40	4–48.0	288.0	142	.493	1.305	.124	3.397		
	10:00	4–15.0	255.0	127	.498	1.316	.140	3.402		
	10:20	4–16.6	256.6	132	.515	1.362	.135	3.414		
Extra	10:30	3–54.4	234.4	114	.486	1.290	.153			
	10:40	4–27.2	267.2	130	.486	1.290	.134	3.397		
	11:00	4–17.1	257.1	130	.505	1.340	.139	3.403		
	11:20	4–29.2	269.2	142	.527	1.395	.133	3.410		
	11:40	3–57.4	237.4	121	.510	1.350	.151	3.415		
	12 M.	4– 3.2	243.2	122	.502	1.325	.147	3.415		80.5
					Means	1.344	.1380	3.405	1.337	

LYONS POINT FLUME. Width, 18.75 ft. Observer, S. W. E.; Tulane Tail Meter.

A.M.	9:00	5– 0.6	300.6	165	.550	1.285	.125	3.245		
	9:20	5– 2.4	302.4	168	.555	1.295	.124			
	9:40	5– 1.4	301.4	166	.551	1.287	.124	3.244		
	10:00	5– 2.6	302.6	169	.558	1.300	.124			
Extra	10:10	5– 2.0	302.0	164	.543	1.266	.124			
	10:20	5– 2.0	302.0	165	.546	1.295	.124	3.244		
	10:40	5– 0.0	300.0	169	.563	1.310	.125			
	11:00	5– 1.8	301.8	166	.550	1.285	.124			
	11:20	5– 0.2	300.2	166	.553	1.291	.125			
	11:40	4–59.8	299.8	168	.560	1.310	.125			
	12 M.	5– 0.5	300.5	170	.566	1.320	.125	3.244		78.5
					Means	1.295	.1244	3.244	1.289	

$$\frac{80.5-78.5}{80.5}=\frac{2.0}{80.5}=2.48 \text{ per cent.}$$

and is known as the Lyons Point flume. Here a second observer was stationed.

All gates and openings from the canal were carefully closed, so that the losses from this source were practically *nil*. The pumping plant was carefully operated at uniform speed, so that a constant flow was maintained. Observations were begun at 9 A.M. and repeated at intervals of twenty minutes until 12 M. At 3 P.M. they were resumed, but the observers had exchanged positions but continued to use the same instruments each had used in the forenoon.

Traverses were made at 0.2 and 0.8 depth, and then the mean depth taken at ten different stations across the flume. The results are given in the accompanying tables. It will be seen that the results are very uniform. Corrections were made

BENOIT FLUME. Observer, S. W. E.; Tulane Tail Meter.

Hour.		Time. M. Sec.	Secs.	Revs.	Revs. per Sec.	*Vr.*	*Vc.*	Mean Depth. Ft.	*V.*	*Q.*
P.M.	3:00	5- 0.8	300.8	169	.562	1.310	.119	3.413		
	3:20	4-59.6	299.6	169	.565	1.318	.119			
	3:40	4-58.5	298.5	170	.569	1.325	.120			
	4:00	5- 2.4	302.4	160	.529	1.235	.118	3.396		
Extra	4:10	5- 1.2	301.2	157	.522	1.220	.119			
	4:20	5- 0.5	300.5	160	.532	1.242	.119			
Extra	4:30	4-59.8	299.8	160	.533	1.245	.119			
	4:40	4-49.8	289.8	166	.573	1.330	.123			
	5:00	4-57.3	297.3	171	.575	1.340	.120	3.416		78.1
					Means	1.285	.1195	3.408	1.280	

LYONS POINT FLUME. Observer, W. B. G.; Rod Meter No. 112.

Hour.		Time. M. Sec.	Secs.	Revs.	Revs. per Sec.	*Vr.*	*Vc.*	Mean Depth. Ft.	*V.*	*Q.*
P.M.	3:00	4-10.5	250.5	121	.483	1.275	.149	3.269		
	3:20	4-45.2	285.2	136	.477	1.262	.131	3.270		
	3:40	4- 7.8	247.8	118	.477	1.262	.151	3.269		
	4:00	4-35.0	275.0	130	.472	1.255	.136	3.265		
	4:20	4-26.2	266.2	124	.466	1.240	.141	3.264		
	4:40	4-37.1	277.1	128	.462	1.230	.135	3.253		
	5:00	4-25.2	265.2	123	.464	1.235	.141	3.258		76.2
					Means	1.251	.1406	3.264	1.244	

$$\frac{78.1-76.2}{78.1}=\frac{1.9}{78.1}=2.43 \text{ per cent.}$$

for the velocity with which the meter was moved at right angles to the axis of flume. The velocity parallel to the axis of flume is designated by V.

The results for the work of the forenoon and those obtained in the afternoon show a remarkable agreement so far as losses are concerned. The loss between the two flumes averaged 2.45 per cent., and 2.45 divided by 3.08 gives a loss of nearly 0.8 per cent. per mile.

It will be of interest to analyze briefly these results to form some idea of the part probably due to seepage and that due to evaporation. The Rice Experiment Station at Crowley, La., is located about fifteen miles northeast of this canal. The weather conditions were uniform over that part of the state on August 7, 1911. It was a typical hot summer day, and therefore observations taken at Crowley will apply at the canal.

The following observations were kindly furnished by Mr. J. Mitchell Jenkins, special agent, Bureau of Plant Industry, United States Department of Agriculture, Crowley, La.

Air temperature, 8:30 A.M.	85 degrees fahr.	
Maximum temperature	93.5 " "	
Minimum temperature	73.5 " "	(night of August 7, 1911).

PSYCHROMETER READINGS.

Hour.	Wet Bulb.	Dry Bulb.	Per Cent. Saturation.
8:30 A.M.	80	85	80
12 M.	78	89	78
5 P.M.	77	91	77

EVAPORATION.

Evaporation from 8:30 A.M. August 7 to 9:00 A.M. August 8, 1911,	0.214
Temperature of water in tank at 8:30 A.M.	85
Maximum temperature of water in tank	94
Minimum temperature of water in tank	80

It is to be regretted that the temperature of the water in the canal was not observed. However, it could not have been very different from that in the tanks at Crowley. Under similar conditions in other parts of the rice country, the writer has had occasion to observe the temperature of water pumped from rivers and bayous into canals, and has usually found it to range from 80 to 89 degrees fahr.

Assuming that as great an evaporation took place from the canal as from the evaporation tanks at Crowley, it is an easy matter to compute the amount. The average width of the four sections shown is 53.25 ft. This multiplied by 16 292 gives 867 550 sq. ft. If it is assumed that the rate of evaporation is

one and one-half times as great from 9 A.M. to 5 P.M. as for the whole twenty-four hours, an estimate of evaporation loss may be arrived at, as follows:

Evaporation 8:30 A.M., August 7, to 9:00 A.M., August 8, 0.214. This is an hourly rate of $\frac{0.214}{24.5} = 0.00873$ inch. $\frac{0.00873}{12} \times 867\,550 = 632$ cu. ft. per hour. $\frac{632}{3600} = 0.175$ cu. ft. per second. $0.175 \times 1.5 = 0.263$ cu. ft. per second loss by evaporation, if our assumptions are true.

Water Measured in Flume (Average).	Cubic Feet per Second, 79.3.	Per Cent. Loss.	Per Cent. Loss per Mile.
Loss due to seepage and evaporation	1.95	2.45	0.80
Loss due to evaporation (as assumed)	0.26	0.33	0.11
Loss due to seepage, by difference	1.69	2.12	0.69

COMPARISONS.

In the annual report of the office of Experiment Stations for 1908, Mr. R. P. Teele, assistant chief of Irrigation Investigations, in an article entitled "Ten Years of Irrigation Investigations," and under the head of "Losses in Transmission," gives the losses of water from many canals in the arid country. The results given by him range in average loss per mile from 51 per cent. to a gain of 0.13 per cent., with the grand average for seventy-two different cases of 5.77 per cent.

Of course, a gain means that water seeps back into a canal, and to thoroughly understand the results, all the details must be known.

It is evident, however, that the conclusion can be drawn that the losses due to seepage in the canals of the rice country are very small as compared with those of the arid West. Engineers with experience in the rice country have always known that the seepage losses were small, but so far as the writer is aware, this is the first attempt to measure the losses accurately.

By referring to the cross sections, it will be seen that the highest velocity (at Section B) could not have exceeded 0.75 ft. per second, while in general it was less than half that amount.

These extremely low velocities are characteristic of canals in the rice country.

The writer was ably assisted in this work by S. W. Elberson, member of this Society.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 1, 1912, for publication in a subsequent number of the JOURNAL.]

STATE HIGHWAY CONSTRUCTION AND MAINTENANCE IN MASSACHUSETTS.

By Arthur W. Dean, Member Boston Society of Civil Engineers.

[Read before the Society May 15, 1912.]

The present year marks the twentieth anniversary of legislation leading to State control of highways in Massachusetts. Agitation for State aid began in 1887, and a bill was presented to the Legislature that year and each subsequent year until 1892, in which year the Legislature passed an act entitled, "An Act to Establish a Commission to Improve the Highways of this Commonwealth."

The essential duties of this Commission were to make an investigation of methods, systems and costs, and recommend legislation necessary for the better construction and maintenance of the highways of the Commonwealth. This Commission was authorized to expend a sum not exceeding $10 000. It made a very comprehensive report to the Legislature of 1893, submitting a draft of a proposed act. This act, with some modifications, was passed in June, 1893, but did not provide any funds for actual road construction. It provided that a county, or two cities or towns, could file a petition with the Massachusetts Highway Commission setting forth that common necessity and convenience required that the Commonwealth acquire a specific highway as a State highway. If the Commission acted favorably upon the petitions, estimates were to be submitted by the Commission to the Legislature, requesting a specific appropriation for each road petitioned for. No such request was made to the Legislature, however, and a bill was passed in 1894 changing quite radically the power of the Commission. This act authorized the selectmen of any town, the mayor and aldermen of any city, or the county commissioners of any county, to petition for a road, and upon favorable action by the Commission, the road could be laid out and constructed without any further act of the Legislature, an appropriation of $300 000 being voted to carry out the provisions of the act in the construction of roads. The Act of 1893, as modified and perfected in 1894 and in subsequent years, is essentially that under which the State roads of to-day are being constructed and maintained. Under this act, appropriations for construction have been made as follows:

1894	$300 000	
1895	400 000	
1896	600 000	
1897	800 000	
1898	400 000	
1899	500 000	
1900	500 000	
1901	500 000	
1902	500 000	
1903	2 500 000	(For construction during a period of five years.)
1907	2 500 000	(For construction during a period of five years.)
Total	$9 500 000	

After the State highways had been constructed in several towns, dissatisfaction was expressed by other towns (in which no State highways were constructed), and this dissatisfaction culminated in an amendment to the State Highway Law in 1900, which amendment provided that 5 per cent. of the amount appropriated in any year for State highway construction should be available for constructing or improving sections of road in towns where no State highways existed, the amount to be expended in any one town being limited under the terms of this amendment. It was amended again in 1901, providing that this 5 per cent. be expended only in towns *under* $1 000 000 valuation, and in the same amendment provision was made for expending 5 per cent. of the annual appropriation for the improvement of roads in towns having a valuation of *over* $1 000 000, provided such towns appropriated an equal amount to go with this portion of the State funds, and provided further that no towns of over $1 000 000 valuation should be eligible to receive this assistance from the State unless they appropriated a certain minimum amount for general highway repairs, based upon the appropriations they had made in previous years. A further amendment was made in 1908, which provided for an allotment of an additional 5 per cent. in towns under $1 000 000 valuation, provided such towns would appropriate a sum equal to that allotted by the Commission. Thus at the present time, 15 per cent. of all general construction appropriations made by the Legislature is set aside by the Commission to be allotted to towns under the conditions enumerated above. The Acts and amendments under which these allotments were made are generally termed the "Small Town Acts," and under these Acts there have been constructed up to the present time about 265 miles of road, at a

cost to the State of approximately \$533 000, and to the towns, of about \$189 000.

During the first year that an appropriation was available, that is, in 1894, about 40 miles of road were laid out as State highways, and constructed or contracted for. At the end of the fiscal year 1911, there were 879.6 miles of State highways constructed.

The earlier roads built by the Commission were nearly all of the macadam type. A few gravel roads were constructed, however, in localities where an excellent quality of gravel could be obtained. The roads were all very thoroughly constructed, much attention being paid to proper foundations and to both ground and surface drainage. The maintenance of these roads, thoroughly and properly constructed as they were, was a very minor problem for the Commission until the advent of the motor vehicle. To one who is constantly facing the maintenance problem at the present time, it is somewhat amusing to note reports made early in the last decade by engineers to the Highway Commission, in which reports they appeared to hesitate in recommending surface repairs costing at the rate of \$200 per mile, and in which reports they described minutely what ought to be done to the roads, the description being given as a kind of apology as well as explanation for the request of such a large amount of money. Until the year 1906, no special treatment was thought of or required for the maintenance of the average macadam State road, except to keep the surface properly bound with stone dust or sand. In 1906, the Commission noted that motor vehicles appeared to remove the binding material from the upper surface of the road and cause raveling. In that year it was not looked upon very seriously, but the following year it was noted quite carefully and experiments were made with surface treatment of the macadam roads with tar. During that year about 7½ miles of macadam road received surface treatment, and since that time about 550 miles have been treated with tar or asphalt, either in construction or surface treatment. While the first bituminous treatment of any extent was applied in 1907, that was not the first year in which oil was used by the Commission for surface treatment of roads. In the year 1899, the steam railroads were using oil to a certain extent as a dust preventive on their road beds, and an experiment was tried in Cottage City, using a so-called "road bed oil" as a dust layer. This oil was very effective as a dust layer for a short time, but after about a month the effect of the oil disappeared and the

road upon which it had been used began to ravel, and thereafter for several years was maintained as previously by using stone dust or sand as a surface binder. Following this brief history, we will now take up the more technical portion of this subject and deal first with construction.

In contemplating the construction of a road, the first thing considered is a proper location, with reference to grade and alignment. The conditions in Massachusetts are such that a very large percentage of the State highways necessarily follow existing roads. Surveys and studies are made, however, in order to secure the best grades and alignment possible under the limitations imposed by local conditions. The next consideration is the drainage and foundation. This subject, having been referred to so many times by various writers, would seem to need little comment at this time, except, however, to affirm that no matter how good and permanent a road surface is to be constructed, proper drainage, foundation and sub-grade are just as essential as in the construction of the old form of macadam and gravel roads; in fact, if any distinction is to be made, more attention should be paid to drainage and foundation on account of the fact that if a modern road breaks up on account of improper sub-grade construction, the expense of repairing the road is greater, consequently more care should be exercised in preparing for the modern surface.

The next consideration is the type of surface to be adopted. This will be dependent upon the nature and amount of traffic to be supported, and upon the grades at which the road is to be constructed. In considering traffic, the fact should not be overlooked that the construction of a new and perfect surface over a proposed route may lead to the deviation of traffic over that route, consequently increasing it greatly above the traffic existing previously to the construction of the road. Many motor enthusiasts now predict that the days of horse-drawn vehicles are numbered, yet the time when horse-drawn vehicles may entirely disappear is surely sufficiently distant that they must be considered at the present time in connection with the type of road surface to be selected, particularly on steep grades. A smooth pavement may be permissible on level grades or on roads with a slight grade, but the per cent. of grade should receive serious consideration before determining the type of surface to be adopted.

As practically no State highways are laid out and constructed within the business sections of cities and towns, wood, brick and

stone block pavements will not be discussed, but we will confine ourselves to bituminous surfaces, such being the type most generally used by the Commission. The conclusion has been reached that in most localities the traffic is such that it is not economical construction to build an ordinary water-bound macadam road and immediately treat it with a surface application of bitumen. While the cost of building a road under this method is only about eight cents per square yard greater than the cost of building an ordinary water-bound macadam road, the result is not commensurate with the additional expense, and is not economical as compared with roads in which the voids in the upper surface are entirely filled with a bituminous material, the expense of this latter treatment being only about twenty cents per square yard greater than the cost of the ordinary water-bound macadam surface. Experience up to the present time appears to warrant the construction of State roads on general through routes by this latter method, that is, by incorporating the bituminous binder in the upper two inches of the surface of the macadam. A method used quite generally this year is as follows: After the sub-grade has been properly prepared, broken stone varying in size from 1¼ to 2½ in. is spread to a uniform thickness varying somewhat with the nature of the anticipated traffic, and dependent also upon the quality of the sub-grade. If the sub-grade is of excellent gravel, a thinner layer may be used in the bottom course than would be used if the sub-grade is of poorer material. The most common thickness of this first course is 3 in. after rolling. This course is thoroughly rolled, the voids being entirely filled with stone dust or other suitable material. After this course has been thoroughly compacted, any dust or dirt that may be left on top is cleaned off, and asphaltic oil applied, using for this application ⅝ gal. to the square yard of 90 per cent. asphalt oil, the application being made while the oil is at a suitable temperature, varying according to the viscosity of the material from 175 degrees to 225 degrees fahr. Immediately after this oil is applied, stone varying from ½ to 1¼ in. in diameter is spread over the oil, the stone having previously been distributed in piles along the side of the road. The thickness of this stone layer should be fairly uniform and should be such that it will roll to about 1½ in. After a partial rolling of this course, a second application of oil is made at the rate of ⅝ of a gallon to the square yard, and it is then lightly covered with additional stone of the same size, after which

a third application of oil is made at the rate of about $\frac{1}{4}$ of a gallon to the square yard, this oil being immediately covered with clean $\frac{1}{2}$-in. screenings, thoroughly watered and rolled. The entire quantity of oil used, when the stone to be bound does not exceed 2 in. in thickness after rolling, should never exceed $1\frac{1}{2}$ gal. to the square yard. Much better results appear to be obtained when water is used before applying the oil in each instance, and during the final rolling of the screenings. It is probable that the alkali in the stone assists in forming an emulsion of water and oil which permits the asphalt to adhere to every part of the surface of the stone. This type of surface has been built successfully during the past two years, giving apparently such good results that, considering the expense, it may be considered as very economical construction for rural highways. It has been demonstrated that the actual cost of such construction above the cost of the ordinary water-bound macadam road, the price of the oil being six and one-half cents per gallon f.o.b. cars within two miles of the work, is not more than twenty cents per square yard. The average cost of the ordinary water-bound macadam surface is sixty cents per square yard, or $5 280 per mile of road 15 ft. in width. The additional cost of the top surface of the road described above, namely, twenty cents per square yard, would make such a road cost eighty cents per square yard, or $7 040 per mile. The cost of maintaining such a road will vary with the traffic, but at this time such roads have not been built for a sufficient length of time to permit positive statement of the average annual cost of maintenance. Under ordinary traffic, however, on rural roads, it is probable that such a road built with proper asphaltic material will require a surface treatment about once in five years, such treatment costing about ten cents per square yard, making the average annual cost of surface maintenance two cents per square yard, or $176 per mile per annum.

Roads under similar traffic conditions have been constructed in a few instances, using the same method for the foundations and bottom course of stone as described above, but using tar as a binder instead of heavy asphalt oil. Ordinarily where the tar is used for a binder, it is used in one application of approximately $1\frac{1}{2}$ gal. to the square yard on top of the second course of stone. Some expense is saved in the first cost of a road built with tar in that it saves a second handling of the stone in the second course, this second course being spread as in an ordinary

water-bound macadam road, and after it has been partially compacted by rolling, refined tar is applied by a pressure distributor, followed by an application of half-inch screenings, the whole being then thoroughly rolled and compacted. The reason for the difference in method of applying the oil and tar is that oil penetrates upward as well as downward, whereas tar has a tendency to penetrate largely downward. Tar has not been used very extensively by the Commission for the reason that tar appears to disintegrate under atmospheric action much more rapidly than asphalt products; this disintegration may be prevented, however, and the life of the material prolonged by applying annually a thin surface coating of refined tar.

A few of the roads controlled by the Commission have such a heavy and varied traffic that either of the above-described methods does not appear to be quite satisfactory. In such cases, roads have been constructed as follows: The first course of stone is spread and thoroughly compacted, stone dust or sand being used to fill the voids and bind the stone to a certain extent. On this is spread a course, not less than 2 in. in thickness as measured after rolling, consisting of stone mixed with a natural asphalt binder of greater viscosity (or less penetration) than the asphalt used in constructing roads by the penetration method. There being reason to believe that natural asphalt products are superior to residuum products for this purpose, the natural asphalt products have been used. To get satisfactory results in such construction, the stone is heated and is then machine-mixed with the hot asphalt, about 17 gal. of asphalt being used to the cubic yard of stone. This asphalt costs nearly double the cost of the ordinary residuum asphalt that is used for penetration work, and the cost of mixing being greater than the cost of construction by penetration brings the cost of this type of road considerably above the cost of the type of road previously described. The average haul of asphalt and stone being 2 miles on a certain road constructed two years ago by this method, the cost of the mixed surface 2 in. in thickness, without any allowance being made for depreciation of machinery, was seventy-five cents per square yard. A road surface of this type, including the bottom course, costs under average conditions with a haul for material not exceeding 2 miles, about $1.10 per square yard, and the cost of maintenance under heavy traffic should not exceed the cost previously given for the maintenance under medium traffic of a road constructed by the penetration method, that is, approximately two cents per square yard per annum.

Another type of road which has been built by the Commission during the past six years in the Cape district is the so-called sand and oil road. This type of road is not recommended for construction where the traffic is constant and heavy, but rather where traffic is comparatively light and where crushed stone or gravel is difficult or expensive to obtain.

The first sand and oil road in Massachusetts was built by the Commission in 1905 and was constructed purely as an experiment. The method used on that road was as follows: All sods and loam were removed from the road. The road was then shaped for a width of 15 ft. to the cross-section to which it was desired to have the road completed. Asphalt oil was then distributed at the rate of about $\frac{3}{4}$ gal. to the square yard, after which the road was harrowed and otherwise worked in order to thoroughly mix the sand and oil together. Another similar application of oil was then made and the harrowing and mixing continued, the surface being then covered with a thin layer of sand and thoroughly rolled, the depressions being filled by adding a little more oil and sand. The following year the road was in such condition that it was absolutely necessary to treat it again, and another layer of oil was applied and covered with sand, rolled, and the depressions filled. This section of road received subsequently slight treatment to fill depressions, and is to-day in very good condition, having had practically no treatment during the past two years. This crude method was not very successful on account of the fact that the surface was in very poor condition for about three years after construction. One method under which several miles of this sand and oil road have been constructed is as follows: The roadbed is first graded to the profile and cross-section desired. Asphalt oil is then distributed on the road at the rate of $\frac{3}{4}$ gal. to the square yard, and immediately thoroughly covered uniformly with sand, and rolled with a light tandem roller. This process is again repeated twice, using less oil in the two subsequent applications. After the third application of oil and sand, the road is watered and thoroughly compacted, using more sand where the oil shows on the surface. The oil used for this method of construction should be of such consistency that it will require heating to about 200 degrees fahr. before application. The sand used should preferably be such that not more than 10 per cent. will pass through a 30-mesh screen. Even if the utmost care is used in the construction of a sand and oil road by this method, defects appear soon after the road is completed, but the expense of repairing these defects is not great, and after all

defects appearing after the first year's construction are repaired, very few defects subsequently appear. The top surface of this type of road has been built at costs varying according to conditions, from twenty to thirty-five cents per square yard, not including cost of grading.

A better though slightly more expensive form of constructing sand and oil roads is to mix heated sand with asphalt oil of a stiff grade, the mixing being done either by hand or machine, using about 16 gal. of oil to the cubic yard of sand, spreading the mixed material so that it will be 3 in. in thickness after rolling, the rolling to be done with a light tandem roller. It has been found difficult to obtain a satisfactorily smooth surface by this method without adding, after the road is completed, a light surface application of asphalt oil, followed immediately by a coat of sand and rolled with a light roller. Under this treatment, the slight depressions in the mixed surface retain a little more oil than the elevations, consequently take a little more sand, and a fairly smooth surface is secured. The cost of constructing this type of road varies from thirty-five to fifty cents per square yard. The speaker desires to emphasize that these sand and oil roads are not recommended, except where the traffic is comparatively light and where crushed stone or gravel roads would be unusually expensive to build.

Still another form of construction that has been used during the past year or two is the so-called built-up gravel road, this type being used where the traffic will permit, and where gravel prevails of a quality suitable for this type of construction, but not suitable for a gravel surface without the use of a foreign binder. The method used is similar to that used for the built-up sand and oil roads. The lower layer of gravel is spread and thoroughly rolled, after which oil and gravel are applied. Three applications of asphalt oil and gravel are made, each layer of oil and gravel being sprinkled and rolled before the subsequent layer is spread. The use of ½ gal. of oil for each of three applications will give a good finished bituminous surface about 1½ in. in thickness. Such a surface must be kept covered with a suitable gravel until all signs of oil exuding to the surface shall have ceased, after which the casual observer could not distinguish any difference between this and a bituminous macadam road. Many short experimental sections have been constructed, using different types, quantities and qualities of wearing material and binder. Some have been found to be entirely useless, others to be excellent, and still others indifferent. The types

already described somewhat in detail as having been used have been adopted as a result of observation of these experimental sections.

The next matter to be considered is maintenance. As previously intimated, the maintenance problem was very simple until the year 1906, at which time the effect of motor vehicles began to be quite evident. The Commission has experimented with practically every kind of material that has been advocated as a road preservative. Changes from year to year in the kind and amount of traffic passing over the roads cause very frequent changes in the kind of material and methods to be used in maintenance of old surfaces. The method most generally used up to the present time has been to protect the surface with a bituminous carpet. The kind of bitumen used on various roads differs with the kind of traffic over the roads. Where the prevailing traffic consists of motor vehicles, it has been found that on old macadam roads, a surface application of asphaltic oil, applied at a temperature of about 225 degrees at the rate of ½ gal. to the square yard, and immediately covered with fine gravel or screenings, having no particles greater than ½ in. in diameter and containing very little dust, makes a very satisfactory protective surface coating. If, however, the traffic consists of both motor vehicles and horse-drawn vehicles, with the latter in excess of the former, such coating is a very temporary protection. This is particularly emphasized when horse-drawn vehicles are heavily loaded on steel tires. There are many miles of macadam road in the state treated as just described that will pass through their fourth season of wear this year. The original cost of this surface application is dependent upon the price of the bitumen, the cost of screenings and the length of haul of both materials. Two years ago the average cost of this treatment on State roads was approximately seven cents per square yard, and as the cost of both labor and materials has been gradually increasing, the cost of such treatment is now greater, and will probably average approximately nine cents per square yard during the present year. It is not to be understood that this treatment, even where the traffic is exclusively motor vehicles, will not require some annual repairs, but the cost of such repairs is very small compared with the first cost of this treatment, such repairs consisting only of covering small patches of road where the bituminous carpet has disappeared on account of poor original workmanship or some other cause. Judging from results obtained in the past, the total surface maintenance cost of many

State roads should not exceed ten cents per square yard for a period of four years. As previously stated, a bituminous carpet with heavy asphaltic oil for a binder is not adapted to roads where horse-drawn vehicles predominate. One method which has been quite extensively used in many places for preserving the roads under this condition is to use a refined tar, the tar appearing to retain a smooth surface under horse-drawn traffic to a greater extent than does the heavy oil. It is perhaps impossible at the present time for any one to state just what weight, quantity and relative proportion of traffic of the two types will be carried successfully and economically by either kind of bitumen, but it is perfectly safe to say that if there are two hundred horse-drawn vehicles and two hundred motor vehicles per day passing over a 15-ft. road, neither of the described types is economical. In such a case the best method is to incorporate the bitumen to a depth of at least 1½ in. of the surface of the road.

In connection with bituminous surfaces, a condition that was not given proper consideration when such surfaces were first used is the proper crown of the road. Before bituminous surfaces were used, practically all macadam roads were built with a crown of ¾ in. to the foot, that appearing from experience to be necessary, but with a bituminous surface such a crown is not only unnecessary but may almost be considered dangerous for traffic. The crown quite generally adapted now for bituminous surfaces is from ¼ to ½ in. per foot. If the surface is properly built, such crown will permit the water to run to the sides and adds to the safety of travelers using either horses or motor vehicles.

The rapid increase in the number and capacity of motor trucks adds another problem to be solved in road building. Unless some limit is placed on the weight per square inch that must be sustained by road surfaces, it may become necessary to practically reconstruct many miles of highway that were built to sustain any traffic anticipated at the time they were constructed, but will not sustain the weight per square inch that now appears probable on account of the apparent competition among manufacturers to build trucks that will carry extremely heavy loads. The solution of this problem will require co-operation on the part of highway engineers and legislators.

[NOTE.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 1, 1912, for publication in a subsequent number of the JOURNAL.]

DEVELOPMENT AND INCREASE IN THE USE OF ASPHALTUM.

By Harry Larkin, Member of the Technical Society of the Pacific Coast.

[Read before the Society June 7, 1912.]

The use of asphaltum is in its infancy to-day; it occupies the same position that Portland and hydraulic cements did twenty years ago. It is a case of modern civilization "rediscovering" the virtues of the two materials, both used centuries ago, but fallen into neglect.

My personal observations have been confined to the Pacific Coast, but in that narrow field I have noted the adoption of hydraulic cement from its first use in San Francisco by Robert Mitchell, in the construction of the Howard Street sewer in 1875, to its extended use in the erection of buildings and engineering enterprises to-day.

I do not think it would be out of place to relate here the story of Mr. Mitchell's first use of cement; to illustrate the prejudice people had against material not in general use and with which they were not familiar. I want to use this to illustrate the position in my eyes in which asphaltum stands to-day. Mr. Mitchell had a contract to replace a small sewer in Howard Street with a larger brick sewer, and it happened that the winter season during its construction was unusually wet. He had great difficulty in taking care of the water coming from the old pipe into his excavation. When he carried the water through his newly constructed brickwork, it washed out the mortar joints and necessitated the tearing out of his work for a considerable distance back in order to make the job acceptable. It happened that a shipment of Portland cement had been received from England by sailing vessel on consignment, and as there was no market for such material here at that time, the shipment was put up at auction, and Mr. Mitchell, hearing of it, bought the entire lot at his own price. After considerable persuasion on his part, the engineers permitted him to substitute Portland cement for lime mortar in the bottom courses of brick, but this permission was granted with grave doubts and was looked upon as simply humoring the fanciful notion of a contractor in difficulty. The result was most surprising both to Mr. Mitchell and the engineers, for he was able to carry the flow of water over comparatively newly constructed work in a manner never

thought of. The Portland cement enabled him to complete his contract on time and in a satisfactory manner.

I might refer to the doubts existing in the minds of engineers and builders many years after that, when the late Mr. George W. Percy built the concrete arched bridge in Golden Gate Park, the Museum building at Stanford University and the stairs and galleries in the Academy of Sciences on Market Street. Almost everybody looked upon it as a fad of Mr. Percy's and entertained doubts of the work's stability. Mr. Richard Keatinge, a member of our Society, has told me of the ridicule he was held up to in Palo Alto, his home town, because of his building the Museum of concrete. But he now glories in the fact, for the Museum stood the earthquake of 1906, while other buildings at the University did not.

Making the comparison here, it is but a few years ago that attention was given to asphaltum as a waterproofing agent, and that combinations of it with sand and gravel were used to any extent for surfacing streets and roads. It is now widely used for roofing, paving and waterproofing, and is gradually being adopted for insulation. The field for its use is unlimited, and when it is better understood, uses will be found for it that are not thought of to-day.

Asphaltum is in that primal state in which it offers a field for promoters, for writers of prospectuses and for the promotion of corporations. An attempt at monopoly in asphaltum came near causing war with Venezuela during Cleveland's administration, and a corporation is now, by virtue of some doubtful patents, collecting royalties on a combination of asphaltum, grit and rock for paving. I see no justice in such a patent, for all asphaltum pavements must be made with sand, gravel, grit and rock in the aggregate, and always have been made in that way since their first use centuries ago. The exact size of the ingredients and their proportions vary with every job and depend upon the use the pavement is to have, its location and the surrounding conditions.

As I understand it, the Warren patents are based upon the combination of large sized rock, one half or two thirds of the thickness of the pavement, together with certain proportions of sand and gravel, all bound together with asphaltum. Such pavements were laid years ago in San Francisco by Larkin & Flaherty, particularly in the business districts, where you will doubtless remember the large pebbles appearing in the sidewalks. The large stones were put in to take the wear, to make the pave-

ment stable, to keep it from moving through heavy traffic. I admire the Warren Brothers' energy in advocating a principle which makes the best asphalt pavement, but under the circumstances I see no justice in the monopoly that has been created by issuing the patent.

During the past few years architects and builders are beginning to realize the economy in use of asphaltum in making houses more habitable and longer lived. The question of waterproofing is in the throes of solution. The necessity of it is more appreciated every day. There are few residences so favorably located but what a small expense incurred in the construction of the foundation and basement would make the house warmer, drier and more agreeable during the rainy season. We have become so accustomed to earth odors permeating our homes that we take it as a matter of course. We avoid using our high basements for other than storage purposes, when, by the proper use of asphaltum in the first construction of the house, considerable space could be gained and made as habitable as any part of it. The application of asphaltum in the footings and exposed surfaces of the foundation will, without doubt, preserve them and prevent the sour odors so noticeable in an old house. The placing of a waterproof course, consisting of two or three layers of felt and asphaltum, in the floors of loft buildings would reduce the insurance, for where fires occur in the upper floors, an immense saving would result by preventing water reaching the stock below.

For roofing buildings, nothing has been found so thoroughly satisfactory as combinations of asphaltum with saturated felts and other materials. The ideal roof covering for comparatively flat surfaces, and the one given the best rating as compared with all other characters of roof coverings by the National Board of Fire Underwriters, consists of at least five layers of saturated roofing felt, mopped solidly with asphaltum and top-coated, over which is placed one-inch flat tile bedded in cement. This roof covering, to quote from its report,

"Affords a very high degree of fire protection to the roof structure, which is not readily inflammable; which does not carry or communicate fire; which does not give off inflammable vapors or gases in large volume when exposed to high temperatures; which possesses no flying brand hazard; which possesses considerable blanketing influence upon fires within the building; and which is durable and requires repairs or renewals only at very infrequent intervals."

There is no other character of roof covering so favorably rated by the National Board of Fire Underwriters as this, but in the next lower class is mentioned the well-laid five-ply felt and gravel roof so universally used.

In some styles of architecture the roof is exposed to view and adds to the harmony of the design. There is no occasion for the felt and gravel roof to be cast aside in such cases, for if reasonable care is taken, the graveled surface can be made to present a uniform appearance that will not detract from the most artistic design. As for color effect, it is a simple matter to spray the gravel, after it is on, with a silica paint and gain any desired color. I mention this to show that the roofer is not of necessity the crude and dirty plodder his appearance indicates, but that he has a hidden taste for the esthetic that only needs to be called for to show itself. Certain combinations of asphalt roofing are used extensively in Southern California on the "bungalow" so peculiar to that district. Nothing more artistic could be devised than some of these structures illustrated in the current architectural papers.

While on the subject of roofing, I will call your attention to an inconsistency in modern building. Asphalt roofs have been adopted because they give better service than metal; still, architects will persist in putting tin at the bottoms of their light-wells, where it is wet half the year, and these light-wells are the receptacle of all kinds of rubbish. A leak in a light-well is always hard to repair, and its location causes more damage, as a general rule, than if it were on the main roof above. If these light-wells were covered in the same way as the main roof with felt and gravel, and then, just before the completion of the building, the gravel were floated over with a light coat of asphalt mastic, the cost would be no greater than if tin were used, and a surface would be obtained that could not be harmed. I have mentioned these things simply to show the field there is ahead for the use of asphaltum for roof covering. As I said before, the use of asphaltum is in its infancy and is capable of wonderful expansion in the hands of intelligent architects and builders.

The advent of the automobile has demonstrated how necessary it is to use some form of asphaltum as a binder in the wearing surface of our streets and roadways. In cities where the streets have a heavy traffic, great care must be taken in preparing the foundation, and the wearing surface should properly be such an aggregate of materials as will stand the traffic and at the same time furnish a proper foothold for horses.

Under the present practice asphalt streets are really dangerous for horses during the cold and damp weather. This slipperiness can be avoided by the use of coarse materials in the mixture. We must always keep in mind that the asphaltum is simply a binder for the sand, gravel and rock that take wear and really constitute the pavement. Where the surface coating is sand, each grain of which is covered with asphaltum, the large proportion of this asphaltum, which will always be exposed on the surface, will render the pavement smooth in spite of any treatment you may give it. But by incorporating a certain percentage of coarse material, held in place by graded finer materials and asphaltum, we will have a wearing surface with a sufficiently hard, gritty substance exposed that the probability of a horse's slipping will be slight, whatever the weather. This is the principle upon which the Warren Brothers' patent bitulithic pavement is based. It is a good principle, and besides doing away with the slipperiness it makes the pavement stable and less liable to roll into ridges.

In order to insure good work, great care must be taken in the selection of sand, gravel and rock in the laying of asphalt pavements, for the slightest film of dust or loam will prevent a perfect bond with the asphaltum. Where a pavement is laid in courses, it is a great mistake to allow the lower course to lie exposed until covered with dust and dirt before the top finish is applied, for the intervening layer of dirt, be it ever so slight, will effectually break the bond that should exist. The only reason there is for laying a pavement in two or more courses is to make it more compact; the difference in labor in so laying it will eat up what little might be saved in cheaper material in the lower or binder course.

In the construction of our proposed state highways, the great bulk of the materials will be found in the creeks and rivers that the roads will pass over. The character of asphaltum used will depend upon the character of the traffic that each local road will carry. Where there is heavy hauling, good foundations will have to be put in and a carefully prepared mastic pavement applied. On the small feeders, and in localities where there is light traffic, what is known as an oiled road may be built up after the grading and drainage have been attended to. In building these oiled roadways, no set formula can be followed, as the quantity of oil to be applied and the consistency of it depends upon the character of grit at hand. I will say right here, there is considerable manual labor required in all asphalt work, and this human element needs constant supervision. There are

few industries where such judgment, care and experience are needed to insure good work. The little details must be constantly looked after. For instance, having any one or all of the materials in a pavement too hot when they are being mixed may be fatal; the differences in temperature from day to day will have great bearing upon how materials work. These and other contingencies must be met as they arise by efficient superintendence. It is reported that many of the oiled roads in Southern California have not been satisfactory. Without having an opportunity to look into the details, I am inclined to believe the fault lies in the oil being of too light a gravity, that being a peculiarity of all natural oil found in that locality. The asphaltum in the oil is what forms the binder; the volatile matter must be evaporated in time; so a heavy gravity oil will be found necessary in almost every instance to get satisfactory results. It is such failures that impress upon the authorities the necessity and economy of competent engineers and superintendents. It is an unfortunate circumstance that the public has gathered the impression that the handling of asphaltum is simply laborers' work. Time and a few drafts on our pocketbooks will convince us otherwise.

Asphaltum pavements will be universally used in time for stables, creameries, factories and warehouses, when their virtues are more thoroughly understood. There is no character of floor surface that will stand the trucking over and abuse like an asphalt pavement; at the same time, it is the easiest to repair in case any fault should appear. Its elasticity makes it pleasant to stand on as compared with cement, and its ultimate cost as a top finish is no greater. The field ahead is without limit as new uses are being found for it every day. California is producing immense quantities, and of a grade that will compare favorably with the older and better advertised deposits in Trinidad, Venezuela, Sicily and Val de Travers. It is but natural that development in the use of asphaltum will come largely from this state, showing a field for engineers and commercial enterprise at present little developed. California has the goods and the brains. When they are combined, productions will result that will make California again as famous as did her gold mines and her orchards and her vineyards in the past.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 1, 1912, for publication in a subsequent number of the JOURNAL.]

OBITUARY.

William Bouton.

MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

WILLIAM BOUTON died of heart failure at his home in St. Louis, Tuesday, April 30, 1912, at 9.45 o'clock P.M., after having been out in the field during the entire day and after having enjoyed the supper with his family and visiting friends.

He was born December 17, 1838, in Pennfield, Calhoun County, Mich., and his father was one of the early pioneers who came from the central part of New York and who was very active as an Abolitionist and later as a Freesoiler and Republican. His mother came of Pennsylvania German antecedents. The genealogical record, published in the "Bouton-Boughton Family," shows descent from John Bouton, a Huguenot who fled from France during the great persecution and settled in Massachusetts in 1635.

William Bouton grew up on a farm, and when fourteen years of age he attended Oliver Academy, in Eaton County of his state, and later took a classical course at Hillsdale College, Michigan, and graduated as Bachelor of Arts in 1861. In September of the same year he joined the Volunteer Army and was elected sergeant of his company, known as "Merrill's Horse," and his cavalry troop went with General Fremont to Springfield, Mo., and during the next year it was there employed in keeping the guerrillas, who were devastating Missouri, in check. In 1863, his company was placed under command of General Davidson and took part in the campaign against Little Rock, Ark.; he was mustered out of the service on September 19, 1864.

He thereupon took up engineering and received his degree at Ann Arbor, the State University of Michigan, in June, 1865. In October of the same year he entered the office of Julius Pitzman, who was at that time county surveyor of St. Louis County; his ability was soon recognized and he was appointed deputy county surveyor of St. Louis County, which position he occupied until the city of St. Louis was separated from the county in 1877. As the lands in the city and county of St.

Louis became more valuable, and as many of the deeds conveying the same had been carelessly drawn, a great many conflicts arose, and Mr. Bouton was of great assistance in establishing new rules and reliable methods for the reëstablishment of the disputed boundaries. From 1879 to 1882, he was a member of the Public School Board of St. Louis and has rendered valuable service as such. In 1885, when Prof. J. B. Johnson prepared his book entitled "Theory and Practice of Surveying," he called upon Mr. Bouton to write the chapter on City Surveying, and this chapter is generally considered to be the most reliable work published on that subject and is a guide for young surveyors. In 1892, the office of Pitzman's Company of Surveyors and Engineers was incorporated, and he served as vice-president and principal assistant of that company to the end of his life.

In 1868, Mr. Bouton married Miss Mary R. Conkin, who faithfully stood at his side for many years and assisted her husband in bringing up a family of children that are of great credit to their parents.

Mr. Bouton became a member of the Engineers' Club of St. Louis in 1884 and held the office of treasurer during 1901 and 1902.

His abrupt honesty, his underlying cheerfulness and his manliness of character have endeared him to a large circle of friends, who mourn his loss greatly.

Julius Pitzman.
Edw. Flad.
M. L. Holman.

ASSOCIATION

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THE ART OF WATER PURIFICATION.

BY C. HERSCHEL KOYL.*

[Read before the Civil Engineers' Society of St. Paul, May 13, 1912.]

ACKNOWLEDGING the courtesy of your invitation, I shall endeavor to confine my remarks to the present state of the art of purification as applied to municipal waters, which, I take it, is the branch of water supply of particular interest to a Society of Civil Engineers.

It is only within two or three years that it has been possible to apply the term "purification," with demonstrable propriety, to any system of water treatment; for in one system we have filtered hard water to make it fit for drinking, and in another system we have softened hard water to make it fit for washing and for boilers, while frequently neither resulting water was suitable for the other purpose; but I hope to be able to prove to you to-night that there is now a system to which the term may be truthfully applied.

Water may carry foreign matter in three states or conditions: first, in suspension, which includes mud, bacteria and anything whose particles can be seen in the water by the naked eye or by the aid of a microscope; second, in solution, which includes gases, alkali salts, limestone and anything whose particles, while in solution, are invisible to the microscope and will go wherever the water goes; third, in colloidal state, which includes a mass of non-crystallizable substances, mostly organic, like glue, albumen, the vegetable slime of the stagnant lakes, and

* Consulting Expert, Great Northern Railway.

the offensive and dangerous slime of sewage — the albuminoid ammonia of the chemist — carried by the rivers, all of which are supposed to be in solution, but which will not follow the water through a close filter, though unfortunately they will go through a sand filter.

Water may be considered satisfactory for drinking if it is clean (that is, free from matter in suspension and from colloids) even though it is hard (that is, charged with limestone) and though it contain considerable amounts of carbonic acid and oxygen. On the other hand, water for washing and for boilers is satisfactory only when it is free from limestone; and boiler water must also be free from carbonic acid and oxygen. It is, therefore, evident at once that any general plan of water purification for a city supply, to include all these purposes, must deliver water clean enough for drinking and soft enough for washing and for boilers. A filter will make the water reasonably clean, but not soft. Happily, the softening process, under the development of the last few years, will make any water cleaner than will any filter.

In the old days, a city filter was a large bed of sand, say five feet deep, through which the water flowed downward until the upper layers of sand were well charged with mud and the lower layers well charged with bacteria, so that a very thorough straining and septic action went on until the sand became too clogged for work and was either taken out, washed and replaced, or altogether taken away.

Nowadays, a city filter is composed of small beds of sand which can have a fine grained coating placed over them in a few minutes, and each of which can be washed independently and as frequently as necessary by reversing the current of water, with the loss of little time and little water and no general stoppage of the work.

The filter is supposed to clear the water of mud, bacteria and the sewage slime referred to as albuminoid ammonia; and a well-managed filter does remove nearly all the mud, about 98 per cent. of the bacteria and about 30 per cent. of the albuminoid ammonia. And during the last four years, a germicide, calcium hypochlorite, introduced by Dr. Leal, of the Jersey Water Company, has been added to the water to oxidize and destroy the remaining germs. The amount of hypochlorite sufficient, if properly applied, to destroy the germs in any water, and yet not enough to be discovered by taste or smell in the finished water, is six pounds per million gallons of water. If

more is found necessary, it is proof that the germicide was not properly mixed with the water, for this is a slow process and requires about twenty minutes of vigorous mechanical stirring after the hypochlorite solution is added to the general mass of water to be sterilized.

I need not discuss more particularly the subject of filters, for doubtless you are familiar with their construction and operation, and their sole object is to remove matter in suspension.

This brings us to the process for removing matters in solution, which was originally put forward only for the purpose of softening water for washing and for boilers, but has now been developed into a process of such accuracy and perfection that it not only softens water with the greatest nicety, but also cleans it better than will any sand filter, because it takes out also nearly all the albuminoid ammonia.

The hardness of natural waters is due almost solely to limestone, either chalk, marble, ordinary limestone (all of which are carbonates) or gypsum (which is a sulphate); and of these, the carbonates are soluble only in water which contains carbonic acid. In 1840, Dr. Thomas Clark, of Aberdeen, Scotland, a graduate in medicine of Glasgow University, who realized the disadvantage of hard water for drinking and other purposes, and who was also professor of chemistry in Marischal College, announced the success of his plan to steal away the extra carbonic acid by adding the proper amount of fresh lime, and, therefore, deposit as a precipitate not only the original limestone, but also the new limestone formed by the union of the carbonic acid and the fresh lime (calcium oxide). There is not known for any ill in nature a more nearly ideal remedy, in theory or in practice; you simply chase out the limestone and leave nothing in its place. But the process for taking out the sulphate is not quite so beautiful, for you must add carbonate of soda, which chases out the limestone but leaves sodium sulphate in its place. In small amounts this is of no consequence, but in large amounts such water may be objectionable for drinking, though it is not injured for wash or boiler water. Lime and sodium carbonate were the reagents originally proposed for this purpose, and they have never been improved on, though a great many chemists have tried.

Soon an effort was made to use the process on a large scale by building pairs of shallow settling basins, within which, alternately, water treated with lime might be allowed to settle. And then there were introduced one after the other, in England and

in France, various improvements in apparatus and in method. The process was made continuous, so that much smaller apparatus sufficed; limewater was used so as to avoid the irregularities of commercial lime; and automatic controlling devices were added, so that the flow of reagents was regulated by the flow of raw water. In such condition the process was brought to this country in 1898; and here have been made the studies and the improvements which have changed this method from a mere process of water softening into a process of general water treatment which may be called in truth " water purification."

As I have said, there was nothing to improve in the chemistry of the subject, for that had all been worked out. It was the physics of the subject which was weak. You have probably seen two rivers with different kinds of water, one muddy and one clean, come to a confluence and flow side by side for perhaps half a mile without mixing of waters, and you can imagine the imperfect mixing resulting from pouring a small stream of lime water and a small stream of soda solution into a large stream of hard water running over a few baffle boards. The mixing was very incomplete, and here was a case requiring the most intimate mixing. Chemical operations are not matters of pounds, or even of ounces; they are matters of molecules. Every drop of water must receive its dose of lime and of soda, or otherwise the reaction will be incomplete, and if the reactions are not completed in their proper time and place, there will be precipitation after the water has passed to the clear water reservoir.

I was intimately connected with the development of the process from 1898 to 1901; and since it was well known that the chemical reactions are almost instantaneous when the molecules of the reagents have reached the molecules of mineral matter in the water, that is, when the mechanical mixing is complete (the test of this being the softness of the water), the first thing I did was to determine by experiment the amount of mechanical mixing necessary to the work; and I found that it required about thirty minutes in the case of clean hard well water, and longer for slimy waters. Thereafter every plant was provided with a mechanical mixing chamber of at least a half hour's capacity; and consisted *in toto* of three tanks, one for the continuous manufacture of limewater, one for the thorough mixing of the raw water with the reagents, and, therefore, the completion of the reactions, and one for settling; and a box containing sodium carbonate solution, set on top of the reaction tank. The incoming raw water, flowing over a water wheel, furnished power

for stirring, and the rate of flow of the raw water determined the rate of flow of the reagents.

As soon as plants were running in which the mixing and, therefore, the reactions and, therefore, the precipitation and the softening were complete when the water reached the settling tank, so that the settling could be done once and for all, I began to notice the wonderful clarity of the water as it flowed from the top of the settling tank. No longer was there any cloudiness, and the water was as transparent as air.

Soon I was called on to take the coloring matter from some soft swampy water. There was nothing in the water from which to make a precipitate, and I had not much hope, for I thought that the coloring matter was in true solution. But I added to the water two substances which together made a precipitate, and this I stirred thoroughly through the water for a half hour and then let it settle. To my surprise the coloring matter (a colloid) had all been gathered up by the precipitate, as dust on the floor is gathered up by wet tea leaves, and the resulting water was indistinguishable from distilled water.

Then I began to think that a process effective with coloring matter in such an exceedingly finely divided condition might perhaps be effective with bacteria; and I sent for a bacteriologist to make some tests. We found that, regardless of the number of bacteria in the raw water, which in his tests ranged from 1 000 to 20 000 per cubic centimeter, the number in the treated and settled water was less than 10, whereas a sand filter seldom leaves less than 50. Likewise, we had the reduction in albuminoid ammonia measured, and found it to be about 80 per cent.

From that day to this I have proclaimed, in season and out of season, that the best way to make city water clean enough to drink is first to make it soft enough to wash with. It took a long time to get the proof in a municipal plant, for nobody wanted to be the first to chance it. In the meantime I had gone off to other professional work, and the business of building softening plants had become an industry in the hands of the young men originally associated with me in developing it; so that when in 1908 the city of McKeesport, Pa., decided to build a municipal water treating plant, I had nothing to do with it, and it was built by the young men in New York under the engineering direction of Mr. Alexander Potter. But it was a credit to the country, even if it wasn't built just as I would have built it, and it proved the point at issue. There was a sand filter attached, for safety, but the settling was so good that at the end

of six months the bacteriologist in charge reported that the water from the settling basin was sometimes better before it reached the filter than after. The treating capacity of the plant is ten million gallons per day, and the weak point in its operation is the lack of vigor in its mixing chamber. The amount of power necessary to effect adequate mechanical stirring is small and, therefore, not expensive, and no practicable number of baffle walls can give an equally good result. The "growing" of the sand grains of the filter is a result not of belated settling, but of belated precipitation; and belated precipitation evidences inadequate mixing. Still the plant was, at the time of construction, by all means the best municipal plant in the world; and the same men have since built two municipal plants in Kentucky, in which there *are* adequate mixing chambers, and from which reports are now probably available. I have mentioned these plants particularly because in my opinion their design and operation come nearest to the ideal. There are, however, other municipal water-treating plants in the United States, some of which might be used for illustration.

One innovation which I introduced two years ago, and for which I hope to get credit from future generations, has great influence on the speed and completeness of settling and makes possible almost as good cleansing results from treating a comparatively soft water as a very hard one. You all know how a crystal of salt, if hung in a saturated solution of salt, will grow by gathering to itself the molecules of salt set free by evaporation of the water. This attractive force is very strong in some cases of precipitation, and exists in all. The only trouble in settling precipitates in water work is in the very fine particles which are formed in parts of the water where there is no precipitate to grow to; and in the old way of feeding the streams of raw water and reagents at the top to flow downward, there were various conditions under which small particles could be born with no attendant. But now by introducing the raw water and the reagents separately at the bottom of the reaction tank and compelling the mixed mass to flow upward, the reaction tank soon becomes loaded with old precipitate to the fullest carrying power of the water, and all precipitation takes place in the presence of a dense mass of old precipitate, to whose particles the molecules of new precipitate are attached as soon as born and there are no cloudy particles of small precipitate to go over to the settling tank. The improvement in settling is very marked, and you will see at once the aid which this method gives

to a water only slightly hard and furnishing only a light precipitate. By this method the density of precipitate in the reaction tank is determined by the upward speed of the water and not at all by the amount of precipitate formed from the water at any one time in the tank. In other words, the cleansing power of the precipitate from a comparatively soft water is as great as that from a very hard water.

The cost of such a plant is approximately that of a sand filter. Any medical man will say that soft water is more healthful for drinking than hard water; and the only possible objection to the general introduction of the system is that the softening of water costs in most cases from two to three cents per thousand gallons, while simple sand filtration costs less than one cent. But as a matter of fact, the soap saved by each family more than pays for the softening of that family's water, and there are other advantages in soft water which are still more valuable.

There is the large item of the damage done to clothes, particularly woolens, by washing them in hard water instead of soft. Every ounce of soap that is put into hard water before it makes a lather is used simply to combine with the calcium and magnesium to soften the water, and the combination of the first pound of soap with the calcium and magnesium in the water produces more than a pound of sticky specks, commonly called curd or soap plaster, of which a considerable portion adheres permanently to the cloth, producing a mass of stiff fibers which will never lie down in the agreeable manner of cloth washed in soft water, and which cause woolens to shrink until they are almost useless. To a lesser degree the same thing happens to cottons and linens: in soft water towns, the cotton bed sheets, after washing, are as smooth as silk; in hard water towns they feel as if they had been rinsed in lime water. I am almost afraid to state in figures the yearly loss to each family in shrunken and matted woolens, in shredded shirts, nightgowns, collars and articles of women's wear, from the excessive rubbing which they get when washed in hard water, but every family knows that the loss is several dollars per year.

The *comfort* of soft water is scarcely to be measured in money, but let any man ask the women of his family how much discomfort they suffer, in washing their hair, from the curd of soap plaster which covers each hair with a sticky coat, makes the hairs adhere to each other, and destroys their natural softness and pliability. It is useless to multiply cases; every woman can

give a dozen reasons why soft water is better in the household than hard water.

Another important aspect of the case is its effect on the development of the city. Some few industries are so associated with the daily life of the people that they must exist, hard water or soft; but these things do not build up a city; they are simply the necessities of its citizens. The things which build up a city are the things which connect it with the outside world, the industries which supply the needs of its neighbors, the people of adjoining counties and states. Factories of all kinds seek the places where they can get their necessities most easily — raw material, soft water and transportation. There is just one kind of manufacturing plant in the world which needs hard water for its work — the brewery; but for every other kind of factory which can locate where it chooses, soft water is a *sine qua non;* and several prosperous cities in the United States owe their manufacturing eminence solely to the natural softness and cleanliness of the local water supply.

I hope I have made good the truth and importance of my statement that at last there is a practicable method of "purification" applicable to municipal waters; and if so, I hope that you will add to the health, comfort, civilization and prosperity of surrounding communities by advocating that hereafter municipal waters be made not only clean, but soft.

[NOTE.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1912, for publication in a subsequent number of the JOURNAL.]

THE VALUE OF SAWMILL REFUSE AS FUEL IN GAS PRODUCERS.

By Chas. E. Snypp, Member of the Louisiana Engineering Society.

[Read before the Society, May 13, 1912.]

I will endeavor to state briefly my experience in the firing of the following fuels in gas producers, namely, bituminous coal, anthracite, coke and coke braize, and sawmill refuse.

Our producer plant was installed for the purpose of burning Pittsburg bituminous coal, guaranteed to furnish gas of about 125 B.t.u. to the engines. As a matter of fact, we operated the plant continuously for about four years on various kinds of coal.

The producer we used was a pressure type Wood producer. The capacity of the producer plant was 840 h.p., consisting of a combination of three units each having a producer shell 8 ft. in diameter by 12 ft. high with steam jacketed top; one wet scrubber 5 ft. by 18 ft. high; one dry scrubber 8 ft. in diameter by 3 ft. high; one pressure fan; one gas holder, and one motor-driven mechanical tar extractor.

The coal was locked in through an air-tight hopper into each of the producer shells. When the workmen poked the fires, the gases under pressure from the blast escaped freely through the poke holes, causing great distress to the workmen. To overcome this difficulty we installed a fan between the dry scrubber and the tar extractor, intending to bring the producer shells under a slight vacuum. This relieved the men of the gases and yet retained our pressure in the holder, thus forcing the gases to our engines under pressure. I will state that this fan was too small to completely accomplish the purposes intended, though it did materialy reduce the quantity of gas escaping from the poke holes, thus relieving the workmen.

After the producer gases are formed, they pass into the wet scrubber, which is an enclosed tower of slats, wherein the water passes in a downward direction and the gases pass upward. The gases are then conducted to a centrifugal mechanical tar extractor which removes most of the tar, and then to a dry scrubber, which is a shell about 8 ft. in diameter and packed with excelsior in layers. The gases then pass through an exhaust fan to the holder and thence to the engines.

The first coal that we burned was Pittsburg bituminous coal, but we found that while this fuel filled the requirements as far as the richness of the gas was concerned, our plant went out of commission at regular intervals in consequence of tar congestion. These intervals came closer and closer together the longer we operated the plant on this coal, on account of greater and greater accumulation of its peculiar tar. In fact, the tar was too heavy for the centrifugal tar extractor, and breakdowns of this machine were frequent. This led us to try other bituminous coals with the idea of reducing the tar nuisance.

After four years of continuous service of the producer plant on various bituminous coals we found that in spite of our selection the whole system of pipes and engines was becoming congested with tar. We also found that it was quite an expensive repair to remove this tar from the engine cylinder rings. In fact, many of the rings had to be cut from the grooves with a cold chisel. We found that a gas plant could not be run for more than five hours on gases from Pittsburg bituminous coals without taking out these tars, as the valves and piston rings would stick. Alabama coals did not do much better.

These Alabama coals were analyzed particularly for fixed carbon and volatile matter in order to select those with a high fixed carbon and a low volatile matter. They gave greater satisfaction because of the reduced quantity of tar, and at the same time furnished a gas that was just as rich as the Pittsburg bituminous, namely, about 125 B.t.u. The Alabama coal, however, introduced a trouble peculiar to itself, which finally forced us to abandon it. The first trouble was that the fuel came to hand of irregular quality, even from the same mine, particularly as to volatile matter and ash. The content of ash was especially unsatisfactory and very irregular, varying from 6½ to 11 per cent. Not only was the content of ash high, but it had the peculiar property of fusing in the producer or forming a solid clinker, which was almost impossible to penetrate with poke bars, and even after penetration with bars and sledges was not brittle enough to break in pieces of a size that could be readily removed from the producer itself. Besides this, the act of fusing cuts off the air from the fuel beds, producing a lean gas, or one low in B.t.u., finally putting that particular producer out of business.

We next resorted to the experiment of burning anthracite coal. Our experiment was limited to a few tons, but the conclusion reached was that we could not produce a gas high enough

in heat value. The best condition did not yield much more than 100 B.t.u. in the gas. Besides, this fuel was too expensive.

The next experiment was to substitute coke and coke braize for anthracite. This furnished a fair quality of about 110 B.t.u. gas in the beginning, but we experienced great difficulty in the producers filling up with ash, and the ash fusing, thus causing cavities which could not be poked out. The quality of the gas sometimes fell as low as 80 B.t.u., thus putting the plant out of commission. When this happened we would have to cool down and sledge the clinkers. I noticed that when the gas became lean we could raise the heat value of the gas by feeding the producer with barrel staves, which would keep us running.

During this interval numerous improvements on the producer plant were made, as follows:

First, the "Z" pipe which conducts the gases from the producer shell to the wet scrubber would frequently become clogged with dry soot, and we found that on account of the bends in the pipe this soot would bake in hard clinkers, thus reducing and eventually choking the pipe. This pipe was replaced by a horizontal pipe extending between the producer shells and the wet scrubber, and a partition was run vertically in the wet scrubber, thus making a downtake which opened directly into the bottom of the wet scrubber.

Second, we found that tar was accumulating in the bottom of the wet scrubber and was very difficult to remove. The metal bottom was replaced by a water seal, extending all over the bottom of the wet scrubber. All other pipes where the gases have a downward trend and a sharp bend were similarly provided with water seals, in order that the tar might readily drop out and wash out, thus facilitating the cleansing of the producer.

While these water seals or water bottoms are essential to the cleansing of the plant, the following little experience will show that they must be used with some judgment. The wet scrubber as installed by Woods & Co. in the ordinary sized machine is about 5 ft. in diameter. The metal bottom of this scrubber was removed, as I have just stated, and a water seal substituted, which proved to be just the thing for a pressure producer. However, I was called upon some months later to go to a plant in Mississippi where they were having trouble with their producer. Upon my arrival I was surprised to see how nicely the producer was working, and noticed that the installation consisted of 140 h.p. engine together with a corresponding

size producer of the suction type. In spite of no apparent difficulty, everybody seemed to be afraid to approach this producer, and the superintendent told me to wait awhile and see what would happen. I did wait awhile and noticed that the engine was drawing gas under a head of about 3 in. of water and this was gradually increasing until some hours afterwards it reached 5 in., and then ran rapidly to 10 in. Then there was a terrific explosion which blew through the seal and blew the poke hole castings and the plugs from the top of the producer. The negro stoker happened to be on top handling a wheelbarrow of coal, and he must have been a new hand or a nervous one, as the last I saw of him was that he was tumbling toward the ground with the wheelbarrow of coal, a distance of about 15 ft., and I noted particularly that he landed on his feet and ran down the hillside. The only reason that I did not leave was that I was penned in by a guard rail. The after-effect of this explosion was that the remaining water seal was alternately drawn in and expelled by numerous puffs that followed. It was apparent to me at once that what had really happened was that the engine had drawn up the water from the seal and admitted a large influx of air, which no doubt made the proper mixture for causing an explosion. The remedy applied was very simple. The opening on the water seal under the scrubber was restricted in size so that no great quantity of water could be drawn in suddenly. The plant ran along afterwards without any trouble whatever, with simply working the beds and removing the clinker when the draft became obstructed. You will pardon this digression.

On account of these various troubles and because of the increase in heating value of producing gases made with barrel staves referred to before, I was prompted to try sawmill refuse in the producers, and found very much to my satisfaction that we were able to operate the plant continuously on about 130 to 135 B.t.u. gas, and the plant was more reliable on account of the even quality of gas. After about a month of use of this refuse fuel our tar troubles began to disappear, and now after using this fuel for a couple of years it is a very rare occurrence to have an inlet valve or an exhaust valve stick in the engines on account of tar, or carbon deposits. In fact, we have discarded the dry scrubber altogether and we even operated one week without a tar extractor at all, on account of that machine needing repair. This illustrates how well the sawmill refuse has solved the problem in our case when it is recalled that we could not run even five hours on coal without removing the tar.

The refuse that we use is known as "cypress hog." It consists of about 50 per cent. of sawdust and 50 per cent. of chips, such as are discharged from the "hog," which is a machine used by sawmills to destroy their refuse. This material runs from 30 to 55 per cent. moisture, and this moisture seems to be necessary for best working conditions.

I will state that we have to guard against the sawdust blowing over into the pipes which conduct the gases to the wet scrubber. This is probably a local trouble, due, no doubt, to the strength of the blast that we use in order to get capacity. We have been able to realize full capacity using sawmill refuse, and our engines deliver a brake horse-power on about 4½ lb. of this fuel.

The changes necessary to fire sawmill refuse are merely the removing of the coal dump hoppers and substituting a hollow cylinder about 10 ft. high slightly tapered and made larger at the bottom and fitted with a slide gate at both top and bottom; these slides are worked with levers and the sawmill refuse is locked into the producers through these tubes.

To start firing a producer with sawmill refuse it is not necessary to have an underlying bed of cinders or ash to cover the blast pipe. The fuel can be dumped in on the water seal and fire can be started either on top or through the side poke holes. Aside from these conditions, the beds seem to be subject to all conditions prevalent in the firing of coal. A clinker is formed of a brittle nature and can be easily removed with the fine ash. The percentage of ash is so small that a producer can be operated about three weeks before removing the ash.

Cavities and chimneys will burn in the bed, and eternal vigilance and poking are necessary to produce a uniform quality of gas. In order to lessen the labor of poking it is good practice to feed occasionally, say, once a day or when the quality of the gas fluctuates, one or two charges of blocks ranging in size from stove lengths to 15 in. in diameter. These blocks will find their way into the cavities and stop the chimneys, and the producer will respond instantly. I have had cavities form low down in the beds and cause trouble, but we have always succeeded in poking down overlying fuel and closing this cavity.

We also experimented with "pine hog," and we find that it is more efficient fuel for producer gas than "cypress hog." An average of ten analyses made on gas produced from "pine hog" showed 161.4 effective B.t.u. against 130 to 135 for cypress. The reason for this is probably due to the greater heat value of

pine itself as compared with cypress. The analyses of heating value of these two fuels showed that the cypress was 5 540 B.t.u., while pine was 7 605 B.t.u. These are on fuel as received, and, therefore, include moisture. The only reason that we do not use pine is that cypress is more available as far as our plant is concerned, which means that it is cheaper, comparatively speaking, although it is pound for pound a much richer fuel.

I have added below a number of analyses of gas produced from various kinds of fuel that it has been my lot to experiment with in solving our problem.

Kind of Fuel.	No. of Analyses.	Effective B.t.u.	CO_2.
Pittsburg bituminous	15	125.3	9.6
Pittsburg bituminous	6	119.9	9.6
Pittsburg bituminous	8	122.5	9.7
Alabama and Pittsburg bituminous	3	112.7	11.3
Alabama bituminous	9	140.9	9.3
Alabama bituminous	12	112.2	7.8
Alabama bituminous (Rock Castle)	13	104.4	11.4
Pocahontas coke	10	103.1	....
Pocahontas coke	8	97.8	7.2
Nut coal	3	100.4	10.5
Coke braize	2	100.5	10.1
Coke braize	4	113.8	....
Coke braize	4	108.0	6.4
Anthracite coal	39	91.2	12.4
Anthracite coal	11	101.2	9.1
Cypress hog	4	111.3	12.2
Cypress hog	12	134.2	10.3
Cypress hog and petroleum	7	133.2	....
Cypress hog and petroleum	5	135.0	....
Pine hog	11	161.4	9.9

To summarize; the advantages to be derived from burning sawmill refuse where it is available are as follows:

First, little ash, therefore little cleaning to be done.

Second, high grade gas, i. e., gas of higher heat value as compared with other fuels in our type producer.

Third, a lesser quantity of tar, and much more limpid in character.

Fourth, gas of constant quality with less labor.

Fifth, no deadly gases to overcome the workmen.

Sixth, and finally, the all-important factor of lower cost per h.p. hour must not be forgotten.

In conclusion, I wish to explain that there is no intention on my part of casting any reflection on the producer or the original installation that we had. I believe that we were among the first

to burn bituminous coal in our section, and our work was of such character that the producer plant had to be operated twenty-four hours a day and sometimes on Sunday.

Cost of cypress waste fuel (basis $4\frac{1}{2}$ lb. per h.p. hour at 50¢ per ton) equals	0.1125¢ per h.p. hour
Cost of firing $4\frac{1}{2}$ lb.	0.1125¢
Total cost per h.p. hour for cypress waste	0.2250¢
Cost of Pittsburg bituminous coal (basis 1.5 lb. per h.p. hour at $4.10 per ton) equals	0.3075¢ per h.p. hour
Cost of firing 1.5 lb. of Pittsburg bituminous coal	0.0750¢
Total cost per h.p. hour for Pittsburg bituminous coal,	0.3825¢
Cost of Alabama bituminous coal (basis 1.5 lb. per h.p. hour at $2.75 per ton) equals	0.2062¢ per h.p. hour
Cost of firing 1.5 lb. of Alabama bituminous coal	0.0750¢
Total cost per h.p. hour for Alabama bituminous coal,	0.2812¢

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1912, for publication in a subsequent number of the JOURNAL.]

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BRIDGE FOUNDATIONS IN THE COLUMBIA AND WILLAMETTE RIVERS NEAR PORTLAND, OREGON.

BY RALPH MODJESKI, MEMBER OF THE AMERICAN SOCIETY CIVIL ENGINEERS.

[Presented to the Oregon Society of Engineers, April 25, 1912.]

ABOUT six years ago I began work on the Vancouver bridge for the Northern Pacific Railroad. I built the Columbia River and the Willamette River bridges for that company. Since then I have completed the foundations of the Broadway bridge in Portland, so that I have had a little experience in the foundations in this vicinity, and will make them the subject of my informal talk this evening.

The Vancouver bridge is located, as you know, at the city of Vancouver, Wash., on the same site as the bridge that Geo. S. Morison planned and began to build in 1890. At the time we commenced operations there the pivot pier built by Morison was the only visible part of the construction previously begun. There were also traces of the foundations of the shore piers which were to be placed on piles.

The geological condition of the Washington Channel of the Columbia River bridge is briefly as follows: There is a stratum, or rather an underlying bed, of gravel, which is about five or six feet from the surface on the Vancouver bank, and dips quite rapidly towards the Oregon shore, so that five hundred or six hundred feet from the Washington shore it is more than sixty feet below low water, and continues to dip westward.

The three easterly piers and the east abutment, as well as the pier built by Morison, were founded on this gravel bed.

Overlying the gravel is a stratum of practically pure basaltic sand. Coming towards the Oregon shore, the gravel gets beyond the depth of practical pneumatic foundations, so that the caissons had to be stopped in the sand.

The piers in the Washington Channel of the Columbia River bridge are numbered from I to X, No. I being on the Washington shore. This No. I is one of the piers which Morison started to build. A number of piles had been driven at the time. Rather than utilize those piles, I decided to put in a pneumatic caisson, which made it possible to remove the old piles and permitted the substitution of a solid concrete foundation resting on gravel bed. In removing these piles, we found some of them very badly broomed, the ends being split in two and turned up on both sides. (Fig. 1.)

The second pier, which is the pivot pier, had been almost finished in 1890, and all I had to do to make it available for the present bridge was to place a few courses of granite on top of it.

Beyond the draw pier towards Oregon we have eight piers numbered from III to X, all practically alike. The caissons were generally 21 ft. by 59 ft. in horizontal dimensions, and about 40 ft. high. They were of timber filled with concrete. They were launched from launching-ways on the Vancouver shore after they had been built up to a height of 20 ft. The launching-ways had an inclination of about six horizontal to one vertical. They were the same ways which had been used by Geo. A. Lederle, resident engineer for Morison in 1890.

We tried two methods of launching; one, to build the caisson in a vertical position, using suitable blocking; and another, to build it in an inclined position. There was no practical difference between one and the other method, but we finally decided to launch most of them in the inclined position. (Figs. 2 and 3.) The working chamber of the caissons had sides 3 ft. thick with 3-in. planking on the inside, the roof being 2 ft. 6 in. thick with 3-in. planking on the under side. The entire caisson was planked outside with two layers of 3-in. planking, one diagonal and one vertical. After the caissons were properly calked and launched, they were towed into place and landed on bottom in the usual manner. In order to reduce the tendency to scour, the cribs above the bed of the river were made with curved ends. As said before, where gravel was within practical reach, the piers were founded on it; thus Piers I, II, III and IV are resting on gravel. The remaining five piers rest on sand and the cutting edge of their caissons has been sunk to elevation 20, which is

80 ft. below low water. Mr. Morison's plans originally contemplated a depth of 70 ft. below low water. In view of the great importance of this bridge and the somewhat heavier weights these piers are destined to carry, I considered a depth of 80 ft. desirable.

When the matter of the conduct of the work came up, I recommended that the work on the substructure for these bridges be built with the company's own forces; consequently we did this entire work, — the sinking of foundations, building of masonry, etc., in this manner, and no contracts were let except for furnishing materials. Mr. Benjamin L. Crosby was principal assistant engineer in charge of the work, and as soon as appointed he proceeded to order floating equipment and plant for doing the work and to organize the necessary force. The work was managed by him in a most excellent manner and the result of performing it in this way and of his management was that it was very quickly completed and at a very reasonable cost. The greatest depth of sinking accomplished in one day was $11\frac{1}{2}$ ft., which is considered quite good, and I am inclined to think is the record for one day's work. We went through sand throughout, which makes the easiest kind of sinking.

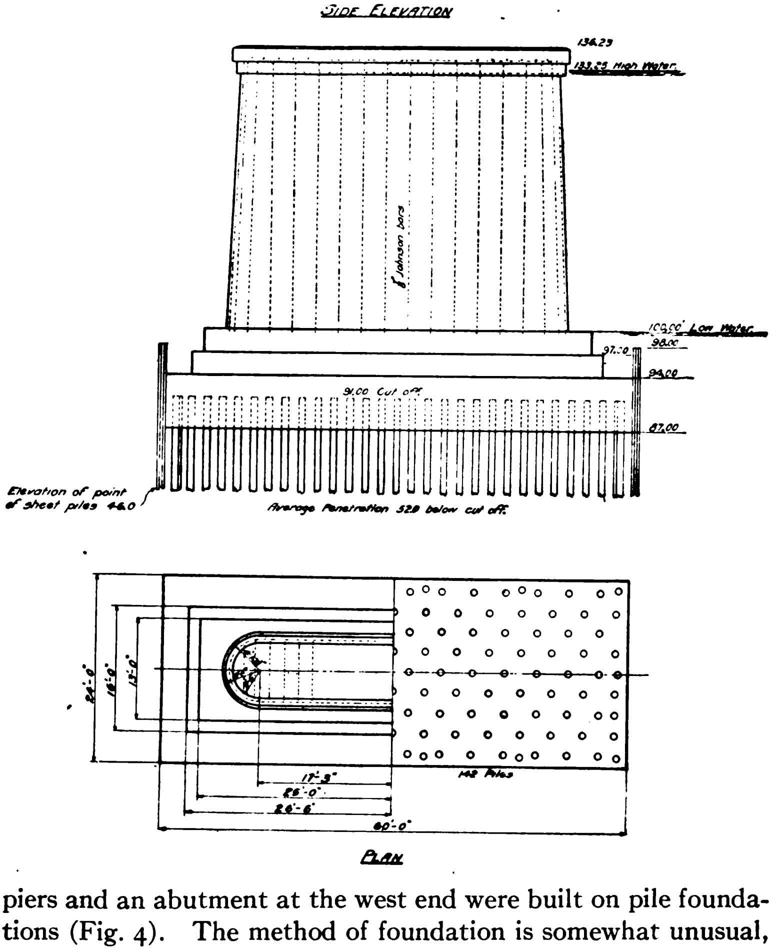
One experience was amusing. We had a strike of the pressure men, or, as they are commonly called, "sand hogs." One day they all walked out at a critical moment. The next morning they came around to investigate and were very much astonished to see the plant steaming away, the sand spouting from the caisson pipes, and every sign of complete activity of the operations. Foreman Taber and his brother were down in the working chamber and kept the work, generally assigned to the whole gang of men, going by themselves. The men were so nonplussed that they returned to work at once.

After we reach the Oregon shore of the Washington Channel, which is that of Hayden or Shaw's Island, the bridge is continued by a viaduct consisting of 86 ft. deck plate girders supported by twenty-six piers, a very convenient number because we were able to letter them from A to Z, the twenty-six letters of the alphabet. I was suspected of making their number just twenty-six for that purpose.

All these concrete piers were founded on piles. The cut-off of the piles was generally 4 ft. above low water and imbedded in concrete 2 ft., which places the bottom of the foundation block at elevation 102. The load on these piles is generally about 22 tons per pile, not counting the supporting resistance of the

soil. The average penetration is about 45 ft. Pier A, which is the nearest to the water's edge, was carried down deeper in anticipation of a probable washing away of the bank at some future date. The piles were cut off at elevation 94, and their tops capped in concrete 4 ft., which places the base of the concrete block at elevation 90.

After crossing Hayden Island in this manner we come to the Oregon Slough, which, as you all know, is quite a river. Ten



piers and an abutment at the west end were built on pile foundations (Fig. 4). The method of foundation is somewhat unusual, and therefore I will explain it more in detail. The depth of water on the bridge line in the slough was from 10 to 30 ft. The bottom consists of silt or silt mixed with clay, soft clay and various materials which make it quite different from pure sand, as in the Washington Channel. Pneumatic foundations would

have been costly and impracticable, for the reason that the compressibility of the river bottom would have required considerable spreading of the foundation to obtain the necessary resistance, hence the caissons would have had to be quite large. This is the way we proceeded. The bottom of the river was first dredged out at the site of the pier to be constructed to a depth slightly below the proposed bottom of the concrete. The required number of piles was then driven and cut off 4 ft. above the proposed bottom of the concrete. The driving of the piles compressed the soil and made it generally rise somewhat between the piles, so that we required some little excavation after the piles were driven. The next operation was the driving of the sheet pile cofferdam built of triple lap sheet piling 11 in. thick. This was rectangular and as nearly as possible of the size desired for the concrete foundation block. Concrete was then deposited under water by means of a tremie, which consisted of a flexible pipe, with a hopper on top. The hopper was always kept full of concrete. By raising the pipe, the concrete was allowed to flow out at the bottom, but care had to be exercised in not letting the entire charge drop out at once. In this way the washing of the cement out of the concrete was very largely prevented. From 6 to 8 ft. of concrete were thus deposited under water. After it was sufficiently set, the cofferdam was pumped out and the remainder of the pier constructed in the usual manner. One of the advantages of this method is that the foundation block can be thoroughly inspected after the water is pumped out of the cofferdam. In each case I found the concrete which was thus deposited under water in perfect condition and fully capable of sustaining the load of the pier. The sheet piling of the cofferdam was driven to a penetration of from 30 to 50 ft. according to the resistance of the material through which it had to go. This sheeting forms a screen around the piles and protects the pier against scour. Some difficulty had been experienced at first in driving the sheet piling so that the pumping could easily be done. After a little experience, however, the cofferdams as

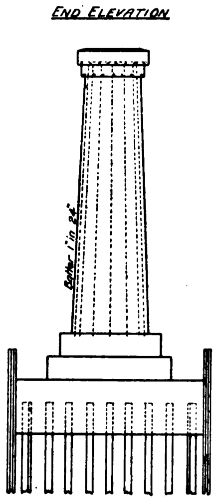


FIG. 4.
OREGON SLOUGH CROSSING, PIERS XII TO XVI INCLUSIVE.

driven were practically water-tight, and the work went on very expeditiously.

The geological situation in the Willamette River is very similar to that in the Washington Channel of the Columbia River, except that the gravel stratum dips in the opposite direction, being nearest to the surface on the west shore. The gravel is much coarser, and in the deeper foundations is replaced by large bowlders and broken-up bed rock. In this bridge there are two abutments, one draw pier and six piers. The draw pier and four piers are between the harbor lines, while the remaining two piers and the abutments are inside of the harbor line. The four river piers and the pivot pier were sunk by the pneumatic process to the gravel or bowlder stratum. At this crossing the bowlder stratum was found to be 27 ft. below low water on the west shore, and 100 ft. below low water on the east shore. Pier A, which is the pier nearest to the east shore, and located just back of the government dike, has been founded on piles, this method being preferred to the pneumatic process on account of economy. The foundation, being placed back of the government dike, was well protected against scour. The piles were driven to refusal with a penetration of from 50 to 55 ft., and they carry a load of about 20 tons per pile, considered all as carried by the piles and none by the soil surrounding the piles. They were cut off below water, and a shallow caisson was sunk over them. The chamber of this caisson was concreted covering the tops of the piles, and then the roof was removed and the sides of the caisson made to act as a cofferdam. The pier was then continued in the dry. A peculiar thing happened after this pier was finished. The east abutment is within 90 ft. from this pier, and the base of rail is about 60 ft. above the original ground. The approach to the bridge at the time the pier was constructed was on a trestle. After the masonry was completed the trestle was replaced by an embankment of sand which, as stated, was about 60 ft. high. Before the embankment was quite completed a settlement of the abutment and of Pier A was noticed. The abutment, which was also founded on piles, settled vertically about 16 in., if I remember rightly, while the pier went down two or three inches and showed a slight leaning towards the embankment. This looked very serious, but the cause was evident. The embankment made after the piers were constructed compressed the entire stratum of sand underneath, but, as anticipated, this compression was limited, and after a certain time the piers came to an equilibrium, and the settlement

FIG. 5. METHOD OF BUILDING AND LAUNCHING CAISSONS, WILLAMETTE RIVER BRIDGE.

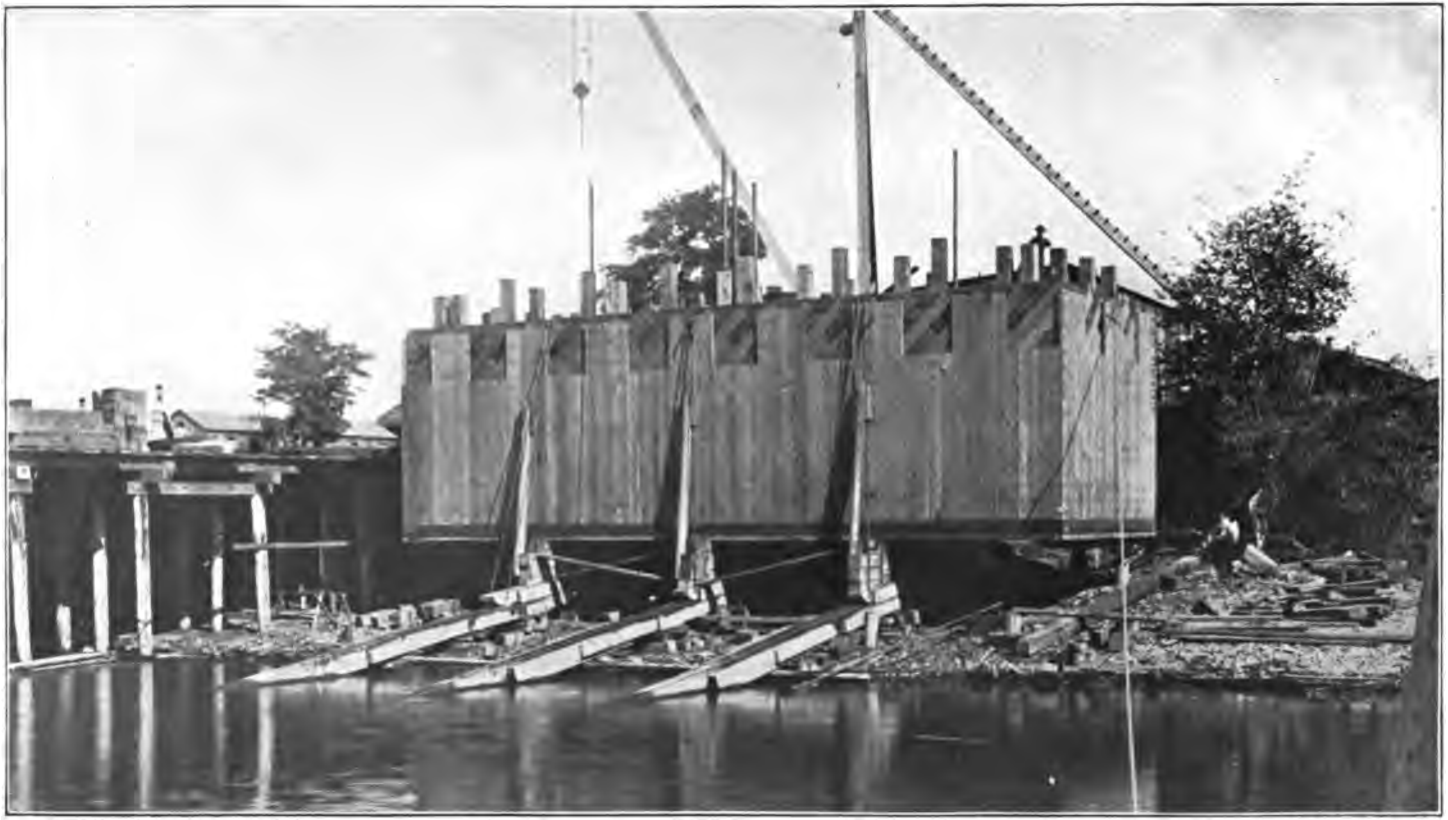


FIG. 2. READY TO LAUNCH CAISSON OF PIER IX, COLUMBIA RIVER BRIDGE.

FIG. 3. LAUNCHING CAISSON OF PIER IX, COLUMBIA RIVER BRIDGE.

Fig. 1. Broomed End of Pile, driven in 1890; shows effect of hard pounding in cement gravel. From old foundation of Pier No. 1, Columbia River Bridge.

Fig. 6. Cutting Edge and Forms for Working Chamber of Concrete Caisson, Pier B, Willamette River Bridge.

Caisson, Pier III (Draw Pier), Willamette River Bridge.

Fig. 7. Caisson towed into place and ready to be launched.

Fig. 8. Launching Caisson by flooding barges; barges partly submerged.

stopped. In order to stop the tilting effect of the pier, I had a riprap embankment put on the river side of the foundation. This seemed to have the desired effect, and the movement stopped entirely. A common opinion prevails that sand is practically incompressible, but it is a fact that fine sand thoroughly saturated with water, and especially the basaltic sand, will compress within certain limits.

The caissons in the Willamette River bridge were almost the exact counterpart of those in the Columbia River bridge. They were 61 ft. by 21 ft. in size, except the draw pier caisson, which was 50 ft. square. The launching of the caissons was a little difficult, there being no suitable place for launching them from inclined ways. The launching was therefore effected as follows:

Two barges were used for that purpose, placed far enough apart to allow the caissons to come between them. Suitable bents were built on the barges and the caissons suspended from them. (See Fig. 5.) After the caissons were built to a height of 20 ft., long screws were attached and the caisson lowered into the water. To obviate the unequal motion of the barges, due to the wash from passing boats, two heavy trusses were built, tying the barges together, one truss being placed at each end. Pier B, which is the pivot pier on the west shore, was also built in a somewhat unusual way. (See Fig. 6.) A reinforced concrete caisson was constructed with 12 by 12 timbers acting as cutting edge, these timbers being held by rods projecting into the concrete of the caisson. Reinforcing bars were placed vertically, horizontally and in an inclined plane parallel to the sides of the working chamber. A sufficient amount of concrete was placed in this caisson to give the required weight. There were two openings or shafts left in the roof, each 4 ft. square. These shafts were provided with recesses, so that bulkheads could be constructed if needed. It was intended to sink this caisson by open excavation, but provision was made to sink it by compressed air if necessary. After a certain depth was reached, it was impossible to keep the water out of the chamber because of the permeable nature of the material, so that bulkheads were placed in the shafts, and the sinking was finished under compressed air.

The caisson for Pier III, or the pivot pier, which was 50 ft. square, was also built on two barges, but the launching was effected by flooding the barges. The caisson as built on the barges was towed first into position, and then the water was admitted into the barges. Two box floats were placed on the

outside edge of each barge. This helped to keep the barges in proper position while being sunk. (Fig. 7 and 8.)

This, I think, is all that is interesting in connection with the foundations of the North Bank Bridges, except the costs, which are shown in the following table. These were obtained with the aid of Mr. Crosby, and were worked up for Piers III and IX of the Columbia River Bridge, Pier III being the first regular pneumatic foundation sunk, and Pier IX the last.

TABLE OF UNIT COSTS OF PNEUMATIC FOUNDATIONS AND MASONRY.

	Approximate Unit Costs.		
	Columbia River Bridge.		Broadway Bridge.
	Pier III.	Pier IX.	Two Main Piers.
Caisson and filling, per cu. ft.	$0.32	$0.27	$0.41
Sinking below low water, including placing of concrete in chamber, per cu. ft.	0.1535	0.0707	0.105
Timber, average cost per M.B.M.	11.10	12.06	....
Cost to frame and build, per M.B.M.	19.10	11.80	....
Cost of rods, bolts, drift bolts, spikes, per M.B.M.	5.43	5.32	....
Cost of locks and shafts, per M. B. M.	7.61	4.58	....
Concrete in caisson and crib, * Total cost per cu. yd.	4.84	4.74	....
Timber in caisson and crib, number ft. B. M.	281 673	343 347	....
Masonry above cribs, cu. yd.:			
Granite	634.2	550.6	9003.5, Total
Concrete backing	312.2	170.6	
Finished pier, including all labor, material, towage, fuel, tools and supplies and handling in yard and freight, Cost per cu. yd.	20.40	20.56	21.95

* Made up as follows:

	Columbia River Bridge. Pier III. Per cu. yd.	Columbia River Bridge. Pier IX. Per cu. yd.
Labor	$0.76	$0.733
Cement	3.26	3.22
Sand, gravel	0.72	0.71
Fuel, etc.	0.10	0.077

By examining the table of costs it will be seen that as the work progressed the costs of labor were considerably reduced, but in some instances the cost of materials was increased with

the demand for such materials. The cost per cubic yard of finished pier included all labor and material, tools, fuel and supplies, and handling in yard and freight. The costs given for the Broadway bridge are those taken from unit prices under which the contract was let and do not, therefore, represent the actual cost of the work, but are given here for comparison only.

The main piers of the Broadway bridge, four in number, were all founded by pneumatic process. The caissons were very similar to those in the Columbia and the Willamette rivers, except that they were larger. The caissons of the main piers were 33 by 90 ft. and 50 ft. high. All four piers rest on the gravel bed at a depth of from 75 to 85 ft. below low water, except Pier VII, which rests on cemented gravel at an elevation of 32.4 ft. below low water. There is nothing very remarkable about the other piers of the Broadway bridge which are all founded on ordinary pile foundations.

[NOTE.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 15, 1912, for publication in a subsequent number of the JOURNAL.]

FLOOD PROTECTION FOR MISSISSIPPI VALLEY.

Introductory Note.

A SPECIAL meeting of the Louisiana Engineering Society was held June 25, 1912, in the Library of the Society, at the call of the President, to whom members of the Society had presented a request from which the following is an extract:

"Losses of both life and property due to recent floods in the lower Mississippi Valley in repetition of past similar occurrences have awakened a most pronounced sentiment and demand on the part of American and European investors in the industries of this section that an effective plan be immediately executed which will absolutely and completely protect this section of the United States from flood conditions.

"The Progressive Union, Contractors' and Builders' Exchange, New Orleans Real Estate Exchange, Algiers Improvement Association, Louisiana Homestead League, Orleans Parish Medical Society and the Louisiana State Medical Society have all discussed in a measure and offered their recommendations relating to river control. The Board of Trade and the Louisiana Engineering Society have as yet, as bodies, taken no action. There are two essentials to the accomplishment of any public work: First, capital; second, engineering construction. With the capital provided, the question is almost entirely one of engineering. Louisiana alone contains more than half of the levees now in service in the United States. The engineers of Louisiana have devoted a large part of their professional careers to the control of rivers, which should give them a prominent part in recommendations to the legislative and executive branches of the federal government, relating to the levee system of protection.

"The object of this meeting is the presentation of different phases of the protection question by various members, in summarized form, and if conclusions can be reached, the issuance of positive recommendations on the part of the Society. As suggested before, after a careful investigation, the sentiment of the eastern, northern and western sections of the country is in hearty accord with that of the South, and without question a bill offered to Congress recommending the continuance of the levee system and its control by the federal government will be favorably considered.

"There has been extensive discussion of river regulation, but the real facts relating to this matter have not been sufficiently disseminated."

The matter of the discussion is summarized as *government control with coöperation of riparian states and cities in the construction and maintenance of levees, bank revetments and channel enlargements for the rivers of the Mississippi Valley as adequate means of flood protection resulting in increased wealth and stability of investment.*

Papers were presented, the authors and titles of which were as follows;

"Reservoir Systems and their Relations to Flood Protection," Capt. C. O. Sherrill, Corps of Engineers, United States Army.

"Possible Ultimate Height of Flood Waters under the Levee System of Protection, with Suggestions as to Typical Sections of Levees." Walstan E. Knobloch, Assistant United States Engineer.

"The Levee System as a Means of Control of the Flood Waters of the Mississippi River." Gen. Arsène Perrilliat, Consulting Engineer.

"Forestation and its Relation to Flood Waters of the Lower Mississippi River." Prof. W. B. Gregory, Tulane University.

"The Effect of Mississippi River Floods on Land Reclamation and Drainage." A. M. Shaw, Consulting Engineer.

"Flood Protection of New Orleans, Topography and Geology of the Mississippi River Valley." Sidney F. Lewis, Chief Engineer, Orleans Levee Board.

"Should the Federal Government now Assist in the Control of the Levee System?" Frank M. Kerr, Chief Engineer, Board of Louisiana State Engineers.

"Increased Wealth to be Derived from Efficient Control of Flood Waters of the Mississippi River." George H. Davis, of Ford, Bacon & Davis, Engineers.

RESERVOIR SYSTEMS AND THEIR RELATIONS TO FLOOD PROTECTION.

By C. O. Sherrill.

There are several related questions bearing on the best means of controlling and utilizing our streams, among which are the relations of forests, reservoirs and soil erosion to stream flow; irrigation to navigable streams; and flood protection by levees, outlets or reservoirs. My subject this evening will be limited to the one phase showing the relation of reservoirs to floods. Others here will take up the several other methods of flood control.

The most vital question at the moment for the people of the lower Mississippi Valley is how best to secure protection from disastrous floods, such as the one now passing, and in the proper solution of this question the sympathy and assistance of the entire country should be ready to aid. Every flood brings forth a multitude of plans, each purporting to be the only one capable of providing the necessary cure, and most of them are brought out as something entirely new, yet each one will, on examination, be found to have been carefully considered and thoroughly investigated years ago. One of these propositions, renewed recently with great energy, has been to control these floods by means of reservoirs located near the headwaters of the tributaries.

In view of the fact that adequate reservoir systems for the control of floods in all streams would strike directly at the seat of the trouble, it seems remarkable that this method should not have been used long ago instead of the merely defensive method of elevation of overflowed land or the erection of levees.

The only perfect remedy for an evil is the removal of the initial cause, just as the sanitarian prevents yellow fever by destroying the germ-carrying mosquito; and in the same way to completely and finally prevent floods one naturally is led to the thought that their surplus waters must be held back in natural or artificial reservoirs; or even going a step further back toward the ultimate cause, why not by mechanical control of rainfall give the desired uniformity of stream flow, and the desired moisture for growing crops at a time of their greatest need. This latter seems fanciful to all of us, yet only a few weeks ago

the rain-makers were once more at work in Kansas attempting to break a two-months drought; and who can say in view of the invention of the aeroplane, wireless telegraphy and other scientific advancement that this control of rainfall will not some day be possible?

If this ultimate cause of disastrous floods, of irregular and insufficient low water flow of streams — of blighted crops — cannot be removed, the next effort should be to secure such a partial remedy as may be afforded by impounding the excess waters as they fall in order to release them when they will be of the least harm and of most benefit to mankind. To those of us who would like to believe that the forces of nature operate according to fixed and beneficent laws, this most irregular and irrational distribution of rainfall does not speak well for nature's designs. In the winter, when commerce is impeded by inclement weather, and agricultural operations are impossible, come the heaviest rains, only to flow away unused and a menace to every human interest along the valley. The ideal of stream flows would be realized if it could be made perfectly uniform throughout the year or at least in proportion to the demands made upon it at different times of the year; and here again, as in rainfall, nature has very poorly done her work, and in so doing has left one of the greatest problems to the solution of river engineers, namely, to compensate for these irregularities of stream flow. In the summer and fall, when crops are to be nourished and moved to markets, the rainfall is least and streams are at their lowest and most inefficient stage; on the other hand, in the winter, when no use of them is possible, rain and snow are abundant and the streams are full to overflowing. Indeed, uniformity, the prime requisite for successful use of any agency of nature, is absolutely lacking. The question, therefore, is, Can this stream flow be made uniform; if so, how and at what cost? To which I must answer that a reasonable degree of uniformity of flow can be secured by adequate systems of reservoirs properly located along streams where the topography is particularly adapted to such reservoirs; but as to the possibility of such control for the Mississippi below Cairo, or of the practicability of the scheme, if possible, it is hoped that the following remarks will be of some assistance in determining.

Reservoirs are of two kinds, natural and artificial. Of the former, the most notable examples are the Great Lakes, which together form a storage basin sufficient to control and give uniformity of flow to the Niagara River with a mean annual

discharge of 232 800 cu. ft. per second, or about 75 per cent. of that of the Ohio, and practically equal to that of the upper Mississippi and Missouri combined. The ratio of the minimum to the maximum mean discharge of the Niagara is 1 to 1.19; of the Missouri, 1 to 29; of the Ohio, 1 to 28; and the upper Mississippi, 1 to 10.3. Without further demonstration, the above is proof positive that under suitable conditions a stream, no matter how large, can be controlled, and the above ratios show further that on the upper Mississippi, where nature has provided more than one thousand storage lakes, the variation is only 1 to 10 against 1 to 28 on the Ohio. Now let us examine this Great Lake storage basin for some indication of the areas of reservoirs required to give this uniformity of flow at its outlet. The total drainage basin of the St. Lawrence above Niagara Falls is 265 950 sq. miles, of which all the rainfall is controlled by Lakes Superior, Michigan, Ontario and Erie, whose water surface alone is 87 400 sq. miles, or more than one third of the entire drainage basin. So, from this analogy, we might safely say that if we could control the entire rainfall of any basin and utilize one third of the area for the actual water surface, the problem would be perfectly solved. Obviously such a proposition is an impossibility; therefore, a further examination is required to learn how much is the best artificial reservoir area that will give the needed protection. This calculation was first made, in 1858, by Humphreys and Abbott in their exhaustive survey of the Mississippi River, and later by Captain Chittenden, in 1897, in his examination of the headwaters of the Missouri for reservoir sites, and very recently by the Pittsburg Flood Commission for controlling the Allegheny and Monongahela rivers in order to protect Pittsburg from flood damage. Humphreys and Abbott found that it would have required the control of the rainfall over 90 000 sq. miles, an area much larger than the whole mountain region drained by the Ohio, in order to hold back the Ohio River floods above the danger stage at Cairo. This report says, "The impracticability of the scheme requires no further demonstration since this flood [of 1858] was of the character which the reservoir system was best adapted to control; it was of the upper tributaries of the Mississippi, all of those below the Ohio being at low stage."

The next investigation, that of Captain Chittenden, has often been quoted as favoring reservoirs; he did favor them, and very properly, at the headwaters of the Missouri for irrigation, and his report was the basis of the present irrigation service,

but he did not consider the scheme practicable for flood control on the lower Mississippi. The Pittsburg Flood Commission found that by the construction of seventeen dams at a cost of $21 672 100, so located on these streams as to hold back the water of 53.8 per cent. of the entire drainage basin above Pittsburg, the greatest flood ever known there would have had its crest reduced from 35.5 to 27 ft., a total reduction of 8 ft. at Pittsburg, but that in certain floods several of these reservoirs filled up before the end of the flood. It was also found that with the assistance of a levee along the entire city front from 9 to 30 ft. high, averaging 14 ft., the city would be protected from overflow; or that a levee 10 to 47 ft. high, averaging 30 ft., would, without any reservoirs, prevent all of the flood damage at a considerably lower cost. The Commission further found that the fifteen next practicable dams would give a flood reduction at Pittsburg of only eight tenths of a foot at an additional cost of $6 000 000 or 17½ per cent. of the total cost of the projected forty-three dams, and these fifteen were accordingly thrown out of consideration as being impracticable. No study of the effect of floods on the Mississippi River was made by this commission, nor on the Ohio, except as incidental to this study of local flood conditions at Pittsburg. Assuming that the data secured by this commission are correct, the question that naturally suggests itself is: If it is necessary to hold back all of the waters falling on 53.8 per cent. of the total drainage basin, assisted by a 14 ft. levee in order to protect a single city, ideally located for such protection by the reservoir system, at the foot of the mountainous area most available for reservoirs, how large an area must be controlled to prevent dangerous floods at and below Cairo with a drainage area above it on the three tributary streams of 908 130 sq. miles? It would be madness to assume a possibility of controlling the entire rainfall of more than 50 per cent. of this vast area, but even suppose one fifth of it, or 180 000 square miles, would be sufficient, then the reservoirs must control the rainfall of an area far larger than the entire mountain region drained by the Ohio and Missouri.

The above considerations alone would condemn the reservoir scheme of flood control without going into the important elements of cost; the physical possibility of securing enough reservoir sites at proper locations; the practical operation of these reservoirs so as to give the desired results; or the damage that would constantly threaten the lower valleys from breaking of these dams.

However, let us see how much a system of reservoirs to control the Ohio would cost. Mr. O. H. Leighton, who precipitated the recent revival of the reservoir-river-control theory in a paper written for the Inland Waterways Commission in 1908, claimed that at a cost of $125 000 000 the Ohio floods could be controlled and the low water flow much benefited. He based his statement on a superficial examination of a few sites on the Monongahela and Allegheny, trusting to small scale maps for information on all other streams. As an indication of the inaccuracy of his determinations I will say that he found a storage capacity of 173 000 000 000 cu. ft. in eighteen reservoirs on the Allegheny and Monongahela rivers, whereas the Pittsburg Flood Commission was able to find only a capacity of 80 000 000-000 cu ft. in forty-three reservoirs, or less than one half as much as the Leighton estimate in more than twice as many reservoirs. A subsequent and more thorough investigation has led to the conclusion that the cost estimated by Mr. Leighton should be increased to five or ten times his figures. Recently, in a letter to Senator Ransdell, Mr. Leighton has receded from many of his former positions and admits that the levee system is preferable for immediate protection.

Ignoring for the moment this practical question of cost, and assuming that, with enough reservoirs, the floods at Cairo could be controlled, where would it be necessary to make the locations so as to secure the benefits desired? Obviously they could not all be placed in the mountainous headwaters where land is cheap and storage basins relatively easy to secure, because frequently (and I might truthfully say generally) destructive floods occur on the lower Ohio when there are no serious flood conditions at Pittsburg or any other headwater locality. For example, the highest water ever known at Pittsburg was on March 15, 1907, when the gage there was 35.5 ft., but we look in vain for any corresponding high stage at Cairo during the next three months. On the contrary, we find that the highest stage (50.3 ft.) at Cairo that year occurred two months earlier, namely, on January 27, while the only flood stage at Pittsburg previous to that date was on January 20, when the river was at the comparatively low stage of 23.3 ft. or 11.7 ft. lower than on March 25; and you will observe that even this stage at Pittsburg had no connection with the highest water at Cairo since only seven days intervened for the crest to travel 964 miles?

Numerous other similar cases could be cited to show that many of the destructive floods occur at points on the lower river

before the upper rivers are in flood. During this year's disastrous high water there were no serious floods at Pittsburg, nor even at Cincinnati, and the reason is that at least eight violent and general storms swept up the Mississippi and Ohio valleys from the Gulf, each one causing additional flood heights throughout the lower basins in advance of the corresponding heights further up on the small tributaries. In this connection the much greater rainfall on a given area along the lower river, as compared with that in the mountains, is not usually given the weight it deserves.

The above facts being true, does it not show conclusively that reservoirs, to be effective in preventing floods at any particular locality on the river, necessarily must be constructed in the immediate vicinity of those localities?

Now, where shall we find sufficient reservoir sites for our purposes on the twenty-three main tributaries of the Ohio below Pittsburg having a total drainage area of 190 000 sq. miles as against that of the basin above Pittsburg with only 18 900 sq. miles? These tributaries flow through the most thickly settled and prosperous sections of the country, where land values are high, and where a large part of the land is too flat for reservoirs, even if other conditions allow their construction. The residents of these thickly settled localities would oppose such constructions on account of the damage to railways and other properties, as well as the menace to health caused by the wide fluctuations of the water surface of the reservoirs, as they would be successively filled and emptied each year.

The presence of dams of the heights proposed, in some cases as much as 250 ft., would be a source of constant danger due to the possible breaking, such as occurred at Johnstown, Pa., where over four thousand people were killed. It may be said that such dangers can be prevented, and so they can, but the fact remains that they do occur even in the best types of earth or concrete construction, as happened only last fall in Austin, Pa. Supposing a dam holding 844 000 000 cu. ft. of water with four others below it on the same stream holding all told nearly 4 000-000 000 cu. ft. should break, can you conceive of the disaster that would result, not only immediately below, but for many hundreds of miles down the valley, due to this vast mass which would probably break each dam in succession on its path of destruction? The above is the condition proposed by the Pittsburg Flood Commission for five dams, one above the other, on one of the branches of the Monongahela. This mass of water would make a volume 20 ft. deep by 1 000 ft. wide by 35 miles

long; and yet writers favoring reservoirs for flood control laugh at the idea of danger from these breaks. No longer ago than October 6, 1911, such a break occurred in the case of two earth and concrete dams on the Black River, Wis. The upper one broke from overtopping, and the mass thus released destroyed a larger one six miles below it. About the same time came the Austin, Pa., disaster, due to the failure of a reinforced concrete dam.

Taking the above brief summary of the facts into consideration, I must conclude that the control of the Mississippi floods by reservoirs is impracticable of accomplishment and that the next best thing must be relied upon, namely, the levee system with bank protection, which should be completed as rapidly as possible.

POSSIBLE ULTIMATE HEIGHT OF FLOOD WATERS UNDER THE LEVEE SYSTEM OF PROTECTION, WITH SUGGESTIONS AS TO TYPICAL SECTIONS OF LEVEES.

By Walstan E. Knobloch.

After each great flood, especially when disastrous effects have been caused by crevasses, we find persons expressing doubt as to the efficiency of levees alone as a means of protection and offering remedies other than levees for the prevention of floods. To these persons it should be made known that the high water of 1912 has not exceeded, except in a few stretches of the river, the expected and long-beforehand-predicted heights.

It is a very difficult matter to predict the ultimate high water of the future for the following reasons: First, the culminations of floods are at different periods in different tributaries of the Mississippi; and, second, a given gage height at any station will not always produce the same gage height at a lower station unless the area of cross-section remains constant between the two stations and there is no change in the resistance of flow or in the flow that gives velocity. Considering these difficulties, it is in my opinion remarkable that the predicted heights of the Mississippi River Commission have been verified so closely.

The following table gives the Mississippi River Commission ultimate high water and the high water of 1912 at the important gage stations on the Mississippi River:

Station.	Mississippi River Commission High Water.	High Water 1912.	Elevation of Zero of Gage Cairo Datum.
Cairo	53.2	54.00	290.84
Memphis	43.6	45.30	203.97
Helena	54.1	54.40	161.98
Arkansas City	56.30	55.30	116.44
Greenville	50.50	50.50	108.00
Vicksburg	55.05	51.50	66.04
Natchez	54.00	51.40	36.89
Red River Landing	52.50	53.20	23.85
Bayou Sara	45.70	47.20	23.95
Baton Rouge	43.20	43.80	20.06
Donaldsonville	34.95	34.80	19.48
College Point	29.80	30.18	21.24
Carrollton	21.00	20.70	20.91
Fort Jackson	9.00	8.50	19.26

The water would have been higher from Memphis to Natchez had it not been for the many crevasses which occurred before the crest of the flood had passed between these points. The water would probably have been somewhat higher at Memphis, Helena and Arkansas City, much higher at Greenville and Vicksburg, and about one and a half to two and a half feet higher at Natchez, but it would have been lower at Red River Landing, Bayou Sara and Baton Rouge. This last statement may appear strange, but the lowering of the water between Arkansas City and Vicksburg diminished the velocity of the current at points below for the reason that the head was lessened and the force that produces velocity was lessened. The slope in the lower river became flat and remained so until the water from crevasses returned over the land and through Old River to the Mississippi River just above Red River Landing.

To what extent this reduction in slope prevailed may be judged by considering this fact: The date of Panther Forest and Salem crevasses was April 12. From this date until April 28, the water fell 4.1 ft. at Vicksburg and rose 3 ft. at Baton Rouge. This fall at Vicksburg, which continued sixteen days, was not felt at Baton Rouge, except only in the way of producing a stand in the water for six days. The water at Baton Rouge, if the effect of crevasses is not felt, begins to fall from six to twelve days after the fall begins at Vicksburg.

For ten miles above Old River the Mississippi River is unleveed and the water from Panther Forest and Salem crevasses returned to the Mississippi River not only through Old River, but over this unleveed land. This sudden addition of a great

volume of water just above Red River Landing caused abnormal gage heights at Red River Landing, Bayou Sara and Baton Rouge, and more so at Bayou Sara for the reason that from Red River Landing extending down to within a short distance of Bayou Sara the water during flood spreads over a large area but is contracted between levees — or levees and hills — at Bayou Sara and below.

Those who have studied the gage relations for stations on the Mississippi River have observed that any cross current running into the river, and especially at a point where the influx is not habitual, will cause the velocity of the water to be checked. The effect is the same as if some obstruction had been placed in the stream, and the water will rise far above the height it might have attained had the same increment come down through the river above. This is often the case at Old River just above Red River Landing and where the flow is sometimes away from and sometimes toward the Mississippi River.

Since 1897, I have observed and studied the effects of return water through Old River and have plotted gage relation curves for each high water. In every case when the direction of flow has been to the Mississippi River there have been abnormal gage heights from Red River Landing down the river for a distance depending on the amount of influx.

The Mississippi River Commission has established a provisional grade which is expected to be 2 ft. above the ultimate high water. In the foregoing table the ultimate high water was obtained by deducting 2 ft. from the Mississippi River Commission grade. This grade is tentative and the Mississippi River Commission, I believe, knows that changes are necessary and has considered increasing the grade in some localities.

In its annual report for 1911, the Mississippi River Commission estimates that little less than 54 000 000 cu. yd. will be required to complete the levee system to grade and standard section. Of the 1 565 miles of levee in the system, there were built, up to 1911 inclusive, 1 496 miles, of which length 636 miles are in the Fourth District. Captain Sherrill has charge of the Fourth District and I, as his assistant on levee work, am familiar with these 636 miles of levee; I feel sure that had there been no crevasses between Arkansas City and Vicksburg, there would have been none in the Fourth District. The crevasses that occurred in the Fourth District were Torras, Hymelia and Cannon. Cannon was closed. Of course, other crevasses occurred on the Mississippi River south of Warrenton, but they

were in private levees not constructed in whole or in part by the United States or by the state and not considered as a part of the system. Without a crevasse between Arkansas City and Vicksburg, the water from Red River Landing down would not only have been lower, but the high water period would have been of shorter duration.

The recent flood was due to an unusual combination of high waters from the Ohio, Cumberland, Tennessee, Upper Mississippi, St. Francis, Arkansas and White rivers, with unusual rains during the flood in the Lower Mississippi River. There is no reason to believe that any future flood will exceed very much, if at all, this last one. Therefore, I believe that the ultimate high water of the future will not vary much from the heights that would have been attained at different stations had there been no crevasses. We should expect higher water from Memphis down to Natchez, lower water from Red River Landing to Donaldsonville, and practically the same stages from College Point to the Head of the Passes.

Now recently a number of persons have asked me about the high water and have made many very absurd recommendations for flood prevention and have insisted that the building of levees raises the bed of the river. I cannot understand by what process of reasoning they assert that levee construction will raise the bed of the river when the natural conclusion should be that increased channel discharge would mean energy tending to deepen and enlarge the channel. In contradiction to this impression or belief that levee construction will raise the bed, I submit the fact that repeated soundings taken over the same sections of the river have proved that this is not true.

Levee Sections.

The Board of District Officers recommended in 1899 that the standard levee cross-section should have an 8 ft. crown with front and rear slopes of 1 on 3 for levees not exceeding 12 ft. in height. For higher levees, a banquette is added on the land side, beginning 8 ft. below the crown with top slope of 1 on 10, rear slope of 1 on 4 and width of 20 ft. Where a levee is built of good material, this section is all that is required, except in cases where levees are built on very loose or porous soil, or where the base is over the bed of some bayou or stream which has silted up and where the underground material is a light blue sand which easily becomes semi-liquid. In such cases the embankment should be built of a different section by increasing the base and

building the lower part of the embankment with slopes of 1 on 6. In this way the hydraulic head is diminished by friction. This extension of the base prevents free seepage under the base, arrests sand-boils and diminishes the subsidence in the base of the levee. How high this 1 on 6 slope should be built depends altogether on the condition of the material under the base of the levee.

At Bougere, in the Lower Tensas Levee District where there was, in places, a subsidence in the base, the levee across Boggy Bayou was built 29.8 ft. high, the lower 11.3 ft. in height was built with slopes of 1 on 6, and the upper 18.5 ft. in height was built with slopes of 1 on 3. There was no subsidence in the base across this bayou, although on each side for a distance of several hundred feet there was subsidence of from 1.0 to 2.2 ft.

Unfortunately, levees must be built of the material found in the neighborhood. The soils along the Mississippi River are loam, sand and a clay known as "buckshot." All of these soils are sometimes found in one neighborhood in different layers and sometimes they are found mixed. The best soil for levee construction is "buckshot," with a small percentage of sand or loam mixed with it. Levees built with this soil do not become easily saturated, do not easily wash, nor slough on the land slope, but they are the ones in which the cray-fish do most of their damaging work. Levees built of loam or sand are more easily saturated and are more apt to slough on the land slope; they are also easily wave-washed; but the cray-fish do not work very much in either of these soils. Levees built entirely of these materials should have the following increased section: Where they are less than 12 ft. in height, the land slope should be 1 on 4, and on higher levees the banquettes should be wider with rear slope of 1 on 5.

That part of the levee system that is below New Orleans, even if built to ample height and section, is subjected to still another destructive agency which may at times become serious enough to threaten that section of the country with overflow. I refer to the damage done by waves during storms at medium as well as high stages of the river and by fast ocean-going steamers. There is no question but that this trouble will be aggravated with the advent of larger ships using our 35 ft. channel through Southwest Pass. Recognizing this, the United States engineers have adopted a method of protection against wave-wash more permanent than the usual wooden revetment, and also more efficient. It consists of placing a concrete facing on the river

slope of the levee and extending it vertically 3 ft. into the berme of the levee. Some of this revetment has been in use five years, and in addition to serving as a protection against wave-wash, has effectively cut off the seepage even on levees of reduced section built by wheelbarrows. The annual cost of clearing and mowing a levee thus protected is cut in half. But probably not the least commendable feature of this revetment is the insurance it offers against perforation by rats and cray-fish. The importance of this can be realized when it is remembered that the Live Oak crevasse was caused by a cray-fish hole in a levee of standard height and section and protected with a cypress revetment not more than two years old. To Mr. John Klorer, United States Junior Engineer, and a member of your Society, is due the credit of devising this method of protection.

During the year ending May 1, 1912, contracts were entered into by the United States for the construction of about 710 000 cu. yd. of levee work at an average cost of 14.33 cents per cu. yd. Even at an advanced price of twenty-five cents per cu. yd. the levee system on the Mississippi River could be completed to the Mississippi River Commission grade and to standard section for less than $15 000 000. If built to a grade 2 ft. higher than the present Mississippi River Commission grade, and to the standard section, the cost would be less than $38 000 000. If this size levee would not satisfy all, they could have concrete facing and curbing placed on the river slope for $40 000 000. This certainly would make our levees safe and strong enough to hold any flood expected in the Mississippi River and very little attention would be required during high water. Can reservoirs or outlets which would reduce the flood heights for any length of the river be built for an amount so small?

THE LEVEE SYSTEM AS A MEANS OF CONTROL OF FLOOD WATERS.

By Arsène Perrilliat.

I had expected to carefully prepare a paper to read before you this evening, as the gentlemen who have preceded me have done. The papers read by them are full of information and concise data, and have great engineering value. Time, however, has failed me to prepare this paper. I am, therefore, going

to trespass upon your time for a few minutes and endeavor to describe to you the evolution of my belief in the levee system, which has come from some twenty years of observation and some study of the Mississippi River. I will deal in generalities perhaps more than in exact figures, and I may also have to beg you to forgive me if I repeat a few of the remarks I had the pleasure of addressing to the Society a short time ago upon a similar subject.

The flood control of the Mississippi River is such a tremendous problem that figures give only a very vague and inadequate conception of what is involved. For instance, if we say that the flood discharge at Vicksburg is 1 700 000 cu. ft. per second, it sounds ordinary and is said quickly, but that is something enormous — 1 700 000 cu. ft. per second. If we try to reduce this to cubic yards of water per twenty-four hours it amounts to 5 600 000 000 cu. yd. per twenty-four hours, 1.2 cu. miles of water for twenty-four hours; in a month it would be 36 cu. miles of water. As a matter of fact, the actual discharge during one year is, on an average, 159 cu. miles of water, a quantity so large that we cannot quite conceive what it means. It is enormous. I would like to also say, incidentally, that at flood stages these 5 600 000 000 cu. yd. of water per twenty-four hours carry in suspension some 7 000 000 cu. yd. of earth or sediment. In other words, there passes Vicksburg in twenty-four hours as many cubic yards of earth on its way to the Gulf as we put on the levees in about one and one-half or two years of construction.

The Mississippi drainage basin (this has been repeated so often it is nearly trite to say it) drains nearly 41 per cent. of the United States. It has an area of 1 250 000 sq. miles. It is some 1 800 miles, if I remember right, wide in longitude, some 1 500 miles long in latitude, draining some ten entire states, parts of twenty-two others and parts of two provinces of Canada. The area drained, the water from which passes Vicksburg, is equivalent to the combined area of Austria, Germany, France, Holland, Italy, Spain, Norway, Portugal and Great Britain. We are dealing, therefore, with a pretty large proposition, something where human agencies, I fear, are so insignificant that all which engineering skill can hope to do is to train, help and try to guide nature to do the work which is required for the protection of property and for the enjoyment of life by those who reside in the valley. It might have been a wise thing for the settlement of the valley to have been delayed some 2 000 or 3 000 years until

it had been filled up and raised so that the annual floods might not inundate and overflow the land. American enterprise, however, decreed otherwise, settled on the banks of the river, found there rich lands, built their few protection levees around isolated localities, and acquired wealth. The population of the alluvial lands increased, attracted by their richness, and we are confronted to-day with a situation of some 30 000 square miles of the richest soil in the United States, perhaps in the world, settled densely, threatened to be settled still more densely, and clamoring for protection against these tremendous agencies of nature. As one of the previous speakers has said, science has not yet gotten to the point of controlling rainfall to a sufficient extent to have it only when we want it and fill the river only bank full. Reservoirs have been discussed by Captain Sherrill. What he has said, and that which I have read, simply confirmed the opinion I have always entertained that the reservoir system might possibly be applied to part of one or two tributaries, at an enormous cost and considerable danger. Eventually these reservoir systems would be crowded out by the demands of increased population, or by their own silting up. In the meanwhile, much money would have been spent and no good accomplished.

We turn then to the next popular outcry: "Outlets."

It seems very reasonable. This tremendous amount of water is pouring down upon us in the months of February, March and April. Make outlets — get it out to the sea — is the cry. This is where I have to repeat myself. The Mississippi River, gentlemen, is not a stream, if I may use the expression, "without a soul." It is not inorganic; it is nearly organic. Alluvial streams generally are organic. They are rivers of their own formation, flowing through a channel or trough in the river-swamp traced by themselves. They are the path which they they have left for themselves to reach the sea. They have filled everything else, but they have left the said channel for their own use, and that channel, gentlemen, it seems to me, like plant life, is organic. If a river has great current velocity, the laws of hydraulics teach us that its transporting power (the power of a river in transporting material along its flow to the sea) varies as the sixth power of its velocity. Its power of erosion (and what I mean by erosion is the power of destroying cohesion of material) varies only as the second power of its velocity, but its transporting power varies as the sixth power of its velocity. Double the velocity and its carrying power becomes sixty-four times as great. This is the secret of its organism. If for any reason this

current velocity is increased and doubled, it has the power of transporting sixty-four times as much material as it had when its velocity was unit, and if you follow this law you will see that a very slight increment in velocity causes a very great increment in silt-carrying capacity. Therefore, the secret of control of alluvial streams, according to river hydraulics, is not to allow the current velocity to slacken. Keep the current velocity going, increase it if possible, and every slight increase in current velocity will mean a tremendous increase (to the sixth power) of the sediment carrying power of that stream.

The alluvial stream is a gigantic hydraulic dredge, and human agency must apply and guide the tremendous energy which is stored up in this water in motion.

Now, how to do it? Get pumps to accelerate these 1 700 000 cu. ft. per second? I think even my expert colleagues of the Sewerage and Water Board would find it very difficult to design such pumps. Therefore, to my mind, increase the current velocity by every means possible, and if that can be done, not only will the sediment brought down from the watersheds of the East, West and North be carried to the sea and deposited there to build new lands, but if that current velocity is increased sufficiently, the stream will assert its right, its privilege of development. It will erode and enlarge its own bed, thereby increasing its section. It will scour out its bottom and become deeper where it is shallow and wide, and it will cave its sides and become wider where it is narrow and deep. In other words, it will increase its size so as to accommodate itself to the quantity of water it must carry.

Just as your arm or your leg will have its muscles developed if you exercise it and train it intelligently, so if the Mississippi River is controlled and guided intelligently it will grow in section so that it will carry its floods to the sea, where we want them to go, without damage to us. Eventually this end will be accomplished by an increased section and current velocity, without any increase of flood height and therefore of danger.

Of course, during the process of development, of training as it were, conditions are often strenuous. I have tried training. The process is pretty strenuous and awfully hard, but when the training has been accomplished and the muscles are hardened, then the work becomes easy. We are now trying to train this river to do its work.

The reservoir system I feel compelled, and reluctantly, to brush aside. The outlet theory I must also brush aside for two

reasons. First, north of the Red River there is no possible outlet, and, second, south of Red River any outlet produces permanent harmful results.

North of Red River, on the west bank, the St. Francis Basin is not an outlet. It is a destructive reservoir. All water that enters it through crevasses fills it up, slackens the current velocity below the crevasse, causes bars, and then returns to the parent stream at Helena, enormously increasing the flood height at that point. This has been proven. On the east bank, the Yazoo Basin, another enormous destructive reservoir, which was used this year, and caused the destruction of I know not how many millions of dollars of property, poured its water back in the river at Vicksburg and increased the flood height. The Tensas Basin, on the west, again may fill up as a reservoir, destroying itself, — the very thing we don't want it to do, — returning at Red River and adding to the flood height. We come, therefore, south of Red River, where, we are sorry to say, two reservoirs filled this year, — the Atchafalaya Basin and the Lafourche Basin. The relief to the flood may have been perhaps 1 or 1½ ft., and the destruction to property enormous. However, I will say temporary relief, for there was a permanent deterioration of the stream bed below its outlets. This is a fact recognized by all hydraulic engineers, from those of the old school down to those familiar with the present highest development in the study of hydraulic science as expounded by the investigations of the Mississippi River. With an outlet, you have a checking of the current velocity below it, a deadening of the current. Having a slackening of the current velocity you ought to have a bar or constriction of the stream below it, and you have it every time. Repeated soundings have shown this. Let the outlet remain open two or say four years, and that stricture becomes permanent. The flood height (which may have been problematically relieved temporarily at the time of the occurrence of the crevasse) at the end of three or four years regains its own, as the parent stream below it has had its section, its carrying capacity, deteriorated by sedimentation, and the combined discharging capacity of the two outlets is only equal to the original capacity of the parent stream. Just as a slight increase in velocity increases tremendously the carrying capacity of the stream, so the converse is true. A slight decrease of the velocity stops tremendously the sediment-carrying capacity of the stream and forms sedimentation below the outlet. This has been repeatedly confirmed; it is no longer a matter of hypothesis or theory. It is a fact.

If we had a clear water stream in a rocky bed, all right, we might have outlets, but we see that in a sedimentary stream outlets are pernicious. The very nature of the remedy proposed by the outlet deteriorates the stream. We have been compelled to abandon the reservoir idea as inefficient and overexpensive. We are then left with only two alternatives: either go on and protect ourselves by increasing our levee system, or else go out of the country. I don't think the people are ready to move out of the country, — they don't seem inclined to do that.

Now, as a matter of fact, bear in mind I have said that we are now during the period of training, that when we have gotten that stream big enough, deep enough, wide enough, it will carry its waters to the Gulf without reaching abnormal flood heights, but we have got to put up with it while training that stream. What has been the experience of the past? In 1882 we had crevasses galore — the entire country overflowed. Levee construction came on in earnest about 1890, the districts raised large sums, the United States government then began lending a helpful hand, much levee work was done between 1890 and 1910. In 1897 we had exceedingly high water, exceeding that of 1882 considerably. I could give you the exact records, but roughly it was considerably over 5 or 6 ft. in many cases. The water in 1897 was held with very little disaster compared to the water in 1882, although flood heights were excessive. This showed what endeavor and the judicious expenditure of money had done. From 1897 to 1903 there were no very high waters. 1903 came with a record-breaking flood and fewer crevasses. It would seem that high waters occur in cycles of approximately eight years, that during cycles of eight years the first two or three years may experience high water, the remaining four or five years low. There does not seem to be any known reason for it, but that seems to be history in the last fifty years where records have been kept. Perhaps later on, when the science of meteorology is more advanced, we shall understand the reason for this. Between 1890 and 1912 we have, with our levee system, been protected absolutely against all ordinary waters and practically against the extraordinary waters of 1897 and 1903. Quite a good deal to say for the levee system. Nobody ever said that the levee system was completed. All of the engineers who are familiar with the subject simply said that they had spent money to the best of their ability and their knowledge. They had to make temporary barriers against the floods, and succeeded in

doing a great deal in protecting the country nine years out of every ten, even fourteen out of every fifteen; that was accomplishing a good deal.

Now, the water of 1912 came upon us, an extraordinarily high water, enormous rainfall. The exact records are not compiled yet, but an enormous rainfall and perhaps greater than that of 1882. The flood wave came down and broke about six important levees. Now, we had accomplished in this country a whole lot of development in a very few years. The impetus which was given to the development of lands in the valley in the last few years has been due to the sense of security which the people have had from their increased protection, and this has been due directly to the levee system. Because we had one year of disaster, which was unfortunately considerable, but by no means universal, and not nearly as great as some yellow newspaper reported (yellow newspapers have to sell by sensational news), the reliability of the levee system is questioned. We must keep on. Is it so difficult? What is the estimate of cost? Sixty million cubic yards for the state of Louisiana, for a 10-ft. crown 3 ft. above the high water of this year, with slopes of 3 and 4 to 1. The slope of the embankments I would double. I believe in big levees; make it 120 000 000 cu. yd. for the state of Louisiana, and another 120 000 000 cu. yd. for the rest of the valley. Two hundred and forty million cubic yards, which will give us 20-ft. crown levees, big section, heavy work, such as the Holland dikes, such section as was not fazed this year by high water and had margin to spare. Two hundred and forty million cubic yards of earthwork at 25 cents per yard, which is an average estimate, would be $60 000 000. I think the Panama Canal has cost, say, $276 000 000 to the present time, and will run up to $400 000 000. Now, $60 000 000 is not so very much for the United States government and the local authorities to put up. If they can't put it up in one year — they could not build the system in one year, it would take six or ten years to do it. In six years it would be $10 000 000 a year. That is not much of a sum; then we should have levees which would protect the Valley forty-nine years out of every fifty years, perhaps for all time, but anyway let us assume forty-nine years out of every fifty years, — that would be a pretty good expenditure. There are something like 19 000 000 acres in the alluvial valley of the Mississippi River, and it would not be idle to say that these would be worth $100 an acre if they were so protected, which would make $1 900 000 000 value for an expenditure of $60 000 000,

about 3 per cent. of the value of the property. Three per cent. expended throughout six years would mean one half of one per cent. annually paid for six years for eventually permanent protection. We pay one half of one per cent. for fire insurance, annually, on our property, without hope of eventual protection, and this is a continuous tax.

Therefore, gentlemen, to my mind, in the light of what we have done in the past with the limited means, with very little help from the national government, the protection we have given to this valley with levees, and levees alone, shows that they are a paying investment and that we should go ahead. The national government now realizes that this is no longer a local problem. The people North, East and West, who deal with us, who sell to us, realize that if we are not buying their goods this year it is because nature has imposed upon us a drainage servitude, the drainage of 41 per cent. of the United States. There is that great ditch which nature had dug in front of our homes. They realize that the burden of this control should not be placed on our shoulders alone. The people of the United States are willing now, I firmly believe, to make liberal appropriations in recognition of that principle. We are willing to keep on taxing ourselves, as far as I can see. Of course, we should like to have the government take full charge of the work so that we might not have to pay levee taxes at all. I should like it very much. However, that which is worth having is worth paying for, and I believe that nine tenths of the right thinking people of the valley are willing to go into their pockets and help protect themselves, saying to the national government, "We can't do it all; you will have to come in and help protect us from that danger, from that suffering and destruction which the drainage of your country imposes upon us." Let us go at it upon that principle. Our cause is good, it can stand on its own merits. We do not need to form alliances with projects of doubtful merit in order to help it along; these might prove entanglements which would delay the recognition of our just demands. Let us stand on our own ground and demand of Congress that assistance which is due to us. Congress will be willing to listen to us. A powerful object lesson has been taught this year, and I think the humanity and good sense of the American people recognize that they owe it to themselves and to us to help in this protection.

FORESTATION AND ITS RELATION TO FLOOD WATERS OF THE LOWER MISSISSIPPI RIVER.

By W. B. Gregory.

The paper assigned to me is one on which a volume might well be written to present the many arguments that have been advanced for and against forestation as a means of flood control. But with full knowledge regarding the length of the program that has been arranged for to-night, it was thought to be proper to limit this paper to concise statement of a few facts and arguments as presented by some of the highest authorities in this country. All that will be presented is already available in libraries, and is doubtless well known to many and especially to engineers.

In the last four or five years a great mass of literature, in which this subject has been discussed, has appeared in the *Engineering News*, the Transactions of the American Society of Civil Engineers, in documents of the House of Representatives at Washington and in various bulletins of the United States Department of Agriculture and the Forestry Bureau.

One of the authorities on the question under consideration is Lt.-Col. (now Gen.) Chittenden of the United States Army. His paper in the Transactions of the American Society of Civil Engineers, Volume 62, March, 1909, is entitled "Forests and Reservoirs in Their Relation to Stream Flow, with Particular Reference to Navigable Rivers."

He opens the subject by stating that it is the commonly accepted theory that forests have a beneficial effect on stream flow:

(1) "By storing the waters from rain and melting snow in the bed of humus that develops under forest cover, preventing their rapid rush to the streams and paying them out gradually afterward, acting as true reservoirs in equalizing the run-off."

(2) "By retarding the snow melting in the spring and prolonging the run-off from that source."

(3) "By increasing precipitation."

(4) "By preventing erosion of the soil on steep slopes and thereby protecting watercourses, canals, reservoirs and similar works from accumulation of silt."

When these statements are examined in detail and proofs are sought that will establish them as demonstrated facts the trouble begins. Colonel Chittenden traces the origin of these popular beliefs largely to the writings of Sir Gustav Wex, chief

engineer on the improvement of the Danube, about forty years ago, and states that while they are still believed by a few engineers they appear to be accepted by the popular mind practically without question.

To establish the truth or falsity of these propositions involves problems containing many variables. The definite proofs that are sought are so modified by the local conditions that data which seem at first to be convincing prove, on closer examination, to lead to an opposite conclusion. As Colonel Chittenden says: "The elements of the problem are so many and so conflicting, the evidence so hard to get, and comparative records are of such recent date, that precise demonstration is scarcely possible."

In discussing the effect of forests upon the run-off from rainfall, Colonel Chittenden affirms that the action of the forest bed to retain water may be accepted as strictly true for average conditions, but that is not true for extreme conditions — great floods and excessive low water — the conditions that determine the character and cost of river control. He points out the fact that great floods due to rainfall occur at times of unusual precipitations, when the humus that covers the forest is thoroughly saturated with water. In such a condition it is unable to exert any restraining influence on the run-off.

The influence of forests on snow melting is discussed by Colonel Chittenden at great length. It is claimed that snow is more evenly distributed in forests than in open country where it has a tendency to drift into deep banks. The snow melting begins in the open country earlier than in the forest. The water from the first melting of snow is absorbed by the snow below. In the forest where shade delays the melting, the greatest amount of melting is likely to be accompanied by a warm rain, in which case the run-off will be that due to the combined rainfall and the snow, and may cause a disastrous flood. On the other hand, the snow from open country will often melt away and disappear before that in the forest has melted and will not cause excessive run-off.

In the discussion of the paper the author is taken to task by Mr. Geo. Otis Smith, Director of the United States Geological Survey; Mr. M. O. Leighton, Chief Hydrographer, United States Geological Survey, and Mr. Gifford Pinchot, because he has overlooked the fact that a great deal of water will soak into the soil under the bed of humus that usually covers a forest, and on numerous other points.

The statement of the delayed melting of snow in forests is

challenged by Mr. Geo. Otis Smith and others, whose observations in the Northwest do not coincide with those of Colonel Chittenden, while some of the men who join in the discussion heartily agree with the author.

Both the criticisms and the replies appear to be from men who are deeply in earnest, — at times they are almost bitter.

The effect of forests on flood control is capable of experimental proof. However, there is very little information of a positive nature that will aid in solving this problem. As a sample of available data, the following is quoted from a press bulletin of the United States Geological Survey, which appeared only last week:

"The report of the Geological Survey is based on the results of exhaustive investigations and specific field tests which have been carried on during the last year. While the Survey has been subjected to frequent criticisms and even bitter attacks, owing to its refusal to submit a perfunctory report assuming that a known and definite relation exists between forests and stream flow in the White Mountain region, the outcome of its investigations must not only satisfy the most radical forest enthusiast, but it precludes the possibility of criticism by those who have opposed the acquisition by the government of any forest lands, on the theory that forest preservation does not affect stream flow. The investigations are believed, indeed, to solve definitely a problem that has long been a source of strenuous contention among scientists, including the friends of forest conservation, and while these investigations have direct reference to the entire White Mountain area, they establish a principle which is of far wider application.

"The hydrometric showing presented in the preliminary report covers results on two small, almost exactly similar drainage basins of about five square miles each, on the east branch of Pemigewasset River, one largely clothed with virgin timber and the other deforested and burned. The facts observed are so striking as to render the position of the Survey impregnable. Careful measurements of precipitation over the areas and of the run-off of the respective streams show that not only was the snow held better in the forested area, but that during a period of seventeen days in April, including three extended storms, the run-off of the streams in the deforested area was a comparative flood, — practically double that of the stream flowing through the forested area. The figures are as follows: Run-off of Shoal Pond Brook (forested area) during three storms in April, 1912, 6.48 in.; run-off of Burnt Brook (deforested area) during the same storms, 12.87 in.

"The results of the Burnt Brook and Shoal Pond Brook studies are held to show that throughout the White Mountains the removal of forest-growth must be expected to decrease the

natural steadiness of dependent streams during the spring months at least."

It is supposed that all the factors have received careful consideration and that the conclusions stated would be found by any other competent scientist who may review the data.

The voluminous paper of Colonel Chittenden, with its accompanying discussions, shows quite clearly that different men may take the same information and interpret it differently. There is much evidence on the other side of the question quite as positive as that just quoted.

As an example of testimony on the opposite side of the question from that presented above, the discussion of Colonel Chittenden's paper by Messrs. Liffingwell and Strong is quoted. In the discussion of extensive data regarding floods on four rivers in California they make this statement: "From the data presented it is seen that the fluctuations of flow in these streams bears a striking relation, and apparently a direct proportion, to the amount of forest covers over the drainage areas."

These statements are given as examples of the conflicting information that is available. Massachusetts and California are far apart, and it may be that local peculiarities in conditions of soils, forests and climate have not been fully considered.

In a recent bulletin by Dr. Willis L. Moore, Chief of the United States Weather Bureau, the following occurs:

"It has frequently been stated that forests control the flow of streams, both in high-water stages and in low-water stages, and that the climate is so materially affected by the cutting away of the forests that droughts have largely increased and that the well-being of future generations is seriously menaced. It is my purpose to present facts and figures that do not support these views, some of which, especially those that pertain to the flow of streams, were held by me up to a few years ago, until a careful study of our own and other records and of the incidents of history caused me to modify my opinions. I shall endeavor not to be dogmatic, but rather to present the reasons for the conclusions that I now entertain, with, so far as may be, statistical and historical evidence to sustain them. And I reserve the right to change or still further modify my views if the presentation of new facts and figures renders such a course logical, and do not consider that I shall stultify myself in so doing."

A little further on he uses these words:

"There are so many reasons why forests should be protected by the state and the nation and economically conserved in the interests of the whole people that it is doing an injury to

a good cause to attempt to bring to its support the false reasoning and mistaken conclusions of enthusiasts, no matter how well meaning they may be or how devoted to high and lofty purposes.

"The general tendency, with growth of population, is to convert forest lands into cultivated fields, and this tendency should not be discouraged unless it can be shown that deforestation has augmented droughts and floods, and I believe that it cannot be shown; I believe that forests should be preserved for themselves alone, or not at all."

Dr. Moore gives some valuable data in regard to the relationship between forests and precipitation, after which he says: "This indicates that instead of a diminishing rainfall we have the evidence that, if there is any variation at all in the precipitaton, it is a slight increase for this region" (referring to New England, where for many years the forests have been disappearing).

He sums the matter up as follows:

"On the whole, it is probable that forests have little to do with the height of floods in main tributaries and principal streams, since they occur only as the result of extensive and heavy rains, after the ground is everywhere saturated, or when heavy warm rains come on the top of deep snows."

The question of erosion is fully discussed in the several papers already referred to and the same difference of opinion already noted is found in the discussions, but time will not permit further reference to this subject.

It is a fact worthy of note that nearly all the engineers who have looked carefully into this matter agree with Colonel Chittenden and Dr. Moore that the forests have very little effect on floods in general and that the effect, if any, may be beneficial or harmful, as the evidence is about equally divided on that point.

At any rate, the flood waters of the lower Mississippi are the run-off from many different sections, widely separated, and conditions causing floods may be quite dissimilar, so that a remedy for one part of the watershed would not apply to another part.

From the available information it seems probable that any effect that forestation could have on our flood problem is practically negligible.

THE EFFECT OF MISSISSIPPI RIVER FLOODS ON LAND RECLAMATION AND DRAINAGE.

By Arthur M. Shaw.

It is assumed that in selecting the subject of this paper the committee had in mind the moral effect which the floods may have on settlers or investors rather than the physical effect of occasional overflows on the engineering works of the various reclamation projects of this section. With this idea in mind, only a moment will be given to the latter phase of the subject.

In most reclamation plans, no cognizance is taken of possible overflow from the Mississippi River, and this is as it should be, for if we were to provide levees of sufficient height and strength to keep out all possible crevasse water, the funds for land reclamation would never become available. Land values have not yet reached the point that would justify this extravagant method of protection. Fortunately, such excessively high levees are not required. The occasional floods, disastrous as they are, do not even now come with sufficient frequency to cause the abandonment of any otherwise worthy reclamation project, and in spite of the discouraging and disheartening experiences which many of them have just passed through, we may expect to see the people returning to their lands, as the waters recede, to find their crops destroyed, it is true, and some minor damage done to their canals and levees, but they will find the actual total damage (beyond the loss of crops and time) to be slight. In some instances it will be found that even the crops are not a total loss, while many of the flooded tracts will become ready for cultivation sufficiently early to permit a fall planting of early maturing vegetables. On account of the greater financial resources of the large planter he is seldom completely ruined as the result of a single crevasse, but the small farmer is better able to recuperate quickly by the flexibility of his farming methods, which enable him to get in a late crop after his fields have once been flooded.

We should now consider the moral effect which river floods have on those who may be investing their money in the development of the wet lands of the state and on those who will settle on these lands after they are reclaimed. This resolves our problem into one of psychology rather than engineering, but it loses none of its interest thereby. It will be conceded that in

spite of the fact that this immediate community was one of the first to be settled in this country, the reclamation of the marsh lands of the lower valley is a comparatively new work, and those who subdue and till these lands are true pioneers. Scores of examples of a similar people, settling in a new country and developing it under even more trying circumstances, show that our occasional river floods will not cause the abandonment of the present plans to reclaim the Louisiana prairies, nor will they even permanently hamper or interfere with such plans. Civilized man has a tenacity of purpose which has enabled him to subdue and make habitable the waste places. As a race, we are aggressive but not nomadic. Individuals may develop a tendency to roam from point to point, but as a people we have never been driven by adversity from a rich and fertile land. There has frequently been an exodus of large bands from one section to another, but these have been made up of the excess of population and such a movement has never resulted in the abandonment of a territory once held. This does not apply to nations and governments, but to the people who settle or make their homes in the land. History is full of examples of entire colonies who have lived through far greater privations and adversities than those experienced by the dwellers in the flood plains of the Mississippi valley. The Cavaliers of Maryland and the Puritans of New England, the Dutch of New York and the Spanish colonists of the Southwest, all entered strange lands and faced death in a thousand forms, but the people have never abandoned their lands.

We have in this room descendants of the courageous French pioneers who braved the perils of the early colony and the persecutions of the Spanish governors to leave to their posterity some of the most beautiful homes of our country.

In our own times we have learned of the trying experiences of the settlers of the Middle West. When the Dakotas, Nebraska and Kansas were first boomed, a few years of plenty for the early settlers were followed by an exceptional cycle of drought and low prices. This occurred just as the boom was at its height and resulted in almost unbelievable loss and suffering. The settlers knew nothing of modern "dry farming" and had not the financial resources to carry them through several years of poor crops. New methods of cultivation have been developed so that similar droughts are now passed through with little resulting loss. Thirty years ago the old-time prairie schooner was still a common sight, and, as a boy, I was particularly im-

pressed by one which passed our home in Northern Illinois bearing this legend:

" In God we trust;
Kansas or bust."

Late in the fall the same wagon passed on its return trip with the added line in fresh paint:

" We busted."

Another discouraged rover returned eastward with the following bit painted on the canvas cover of his schooner:

" Nebraska and irrigation,
Kansas and starvation,
Hayes' administration,
Hell and damnation,
Goin' home to my wife's relations."

This local ebb flow was of short duration, however, and all the agricultural states are now increasing in population and wealth.

We may expect that the flood of this year will affect the reclamation projects of Louisiana adversely, but this effect will not be permanent and prompt resumption of normal conditions is to be expected. The real tide of immigration to this section has scarcely begun and I confidently expect that the next few years will see great numbers of Northern farmers looking to Louisiana for the only cheap productive lands that are now easily available and favorably situated. It hardly need be said that this rather optimistic view of the question should not lessen our efforts to secure the proper regulation of the river. Our losses from this source are out of all proportion to the cost of adequate protection, and no time should be lost in doing whatever may be necessary to insure the lower valley from any possibility of periodical overflows.

We might now consider, not the effect of river floods on land reclamation and drainage but the effect of land reclamation and drainage on river floods. It is to be noted that a large proportion of the money invested in Louisiana reclamation work comes from various sections of the North, and right there is where we are going to develop a tremendous fighting strength in support of proposed federal aid in the proper construction of our river levees. It is generally conceded that where a man's money is, there is his heart (and his vote) also. It is this vital personal interest among men of large affairs in several sections of the country which will make it possible to enact laws providing the

necessary means for proper levee construction. Please do not understand that any claim is made that it will be the Northern investors who will secure the necessary legislation. We must bear the brunt of the fight for additional appropriations and must make this fight an earnest and a hard one, but by properly placing the matter to those non-residents who have here a personal and a selfish interest, we will develop a source of assistance not heretofore available. It is apparent that those owning or living on the reclaimed lands of the valley have little personal interest in the exact method used to control the river, but it is hard to see how their interests can better be safeguarded than by the early construction and proper maintenance of a system of levees which will be of ample height and cross-section to hold in place the Father of Waters.

FLOOD PROTECTION OF NEW ORLEANS. TOPOGRAPHY AND GEOLOGY OF THE MISSISSIPPI RIVER VALLEY.

By Sidney F. Lewis.

Geologists tell us that in Eastern North America, during the Paleozoic ages, the great Appalachian range of mountains lifted their heads high over the sea for centuries and centuries before the western border, the Rocky Mountain range, appeared above the surface. In the cretaceous period of Mesozoic time, the Rocky Mountain region had become dry land, and its present height was gradually attained later in the Tertiary period, and became the western wall of the Mississippi valley.

"To fill in the space between this wall and the older one on the east, nature taxed all her resources of land building agencies, and for ages upon ages the forest, the rain, the river, the glacier, decomposing, pulverizing, transporting and assorting the solid stuff of the mountain sides; plants and animals, living, growing, dying, rotting and mingling their dead tissues with the deader dust of rocks in a soil waiting only the seed of the sower to blossom into new forms of vitality for the use of the heir of the manor, man, when he should come into his princely inheritance, the Mississippi River valley. For there is no subdivision of the earth's surface which, if we take into account its area, the value and diversity of its productions, and the thrift, wealth, intelligence and progressiveness of its population that has its parallel on the globe."

The Mississippi River System.

The great river system of the Mississippi, with its trunk line, penetrates the heart of the most fertile section of the valley for a distance of about 2 500 miles; and its 15 000 miles of navigable tributaries ramify in all directions towards its remote limits. It drains a territory whose area equals in extent the combined area of Austria, Germany, Holland, France, Italy, Portugal, Spain, Norway and Great Britain.

The river itself, in its winding course, covers a range of 6¼ degrees in longitude and 18½ degrees in latitude. The headwaters of its tributaries extend in longitude from New York on the east to Western Montana on the west; and reach in latitude from British America on the north to the Gulf of Mexico on the south; or about 1 800 miles in longitude and 1 500 miles in latitude.

Drainage Area.

This vast drainage area, 1 256 000 sq. miles in extent, is equal to nearly one half of the total area of the United States. It touches thirty-two states, and two provinces of the British possessions. Only eight states to the eastward, and seven states to the westward, lie entirely beyond the confines of this great basin. This stupendous process of land making and extension has not only come down to an immediate and recent geological period, but is in process yet.

At Cairo, Ill., 1 061 miles from the Gulf of Mexico, by the windings of the river, is gathered together the surplus rainfall of nearly a million square miles, concentrated by the confluence of the Tennessee, Cumberland, Ohio, Mississippi and Missouri rivers; the last two uniting something over two hundred miles above. Here heads the Lower or Greater Mississippi.

The last remnant of the Appalachian sea was a narrow prolongation of the Gulf of Mexico extending to this meeting ground of rivers, into the head of which they poured their floods in a group of falls or cataracts of sublime grandeur. In the lapse of ages the detritus brought down by them filled this long frith and transformed it into a sloping alluvial plain of seven hundred miles in length and varying from twenty to forty miles in width, having a descent to the Gulf of about three hundred feet, and embracing an area of 29 790 sq. miles, subject to overflow in its natural state during great floods.

This area is greater than that of the combined area of the state of Massachusetts, 8 315 sq. miles; Rhode Island, 1 250

sq. miles; New Jersey, 7 815 sq. miles, and Maryland, 12 210 sq. miles, or a total of 29 550 sq. miles.

If this area, which surpasses in richness the valley of the Nile, richer than any other portion of this continent, had a population as numerous as the population of Belgium, 550 souls to the square mile, it would contain fully 15 000 000 people. Its tributaries could then be diverted, its headwaters impounded; their power so harnessed as to further the many meritorious projects that are now being agitated and spoken of. What a mighty empire it would then be, how vastly important and how well worthy of and entitled to government encouragement and assistance!

In the year 1538, Hernandez De Soto, one of the conquerors of Peru, a Spanish nobleman of great wealth and influence, with a splendid retinue of knights-errant, penetrated step by step through the wilds of Florida, Georgia, Alabama and Mississippi, until they reached the banks of the Mississippi River, in April, 1541. They and the pioneers of civilization who came after them found this alluvial valley covered by a luxuriant growth of vegetation, forest trees, and deep cane brakes, and periodically covered by the overflowing waters of the river. The description given then will answer for to-day:

"The lapse of over three centuries has not changed the character of the stream. It was then described, as it now is, as more than a mile in width, flowing with a strong current, and by the strength of its waters forcing a channel of great depth. The water was described as being always muddy, and trees and timber were continually floating down the stream."

The pouring rains and melting snow in the springtime through thousands of rivulets, creeks and branches, gathered into mighty floods, and swept down the Mississippi and its tributaries; they generally overtopped the river bank in many places and flowed in a thin sheet of water over the adjacent land. The thick undergrowth on the banks of the stream, by checking the rapid flow of the escaping water heavily charged with silt or sediment during flood periods, would cause the earth and sand held in suspension and carried along by the current to settle, and thus continually build up the banks. But the stronger currents in the rivers themselves wore away and cut the banks into the lower ground in some places; so that the work of building up and tearing down was forever going on, as, indeed, it still is; and consequently the river banks throughout their

length were never built up to high-water mark by the unassisted processes of nature.

Thus it was that when the earliest settlers began to open plantations along the water courses of the alluvial valley, they soon found it desirable for comfort and convenience, if not absolutely necessary for rendering the country habitable, to keep the flood water from flowing across the river banks and over their clearings and plantations.

The most obvious and natural means for preventing such overflow was, of course, to make the banks a little higher with a ridge of earth. Such a ridge, or levee, a few inches or at most a few feet in height, was usually sufficient to protect the immediate front against ordinary floods, and was not a work of great cost or labor. The lower lands back from the river might still be inundated, but this was of little consequence while there was plenty left on the front.

Evolution of the Levee System.

The engineer De la Tour, who laid out New Orleans, in 1717, found it necessary to provide for a levee something over a mile in length to be raised in front of the city to preserve it from overflow, which, however, appears not to have been completed until ten years later, when levees were being built by the riparian owners for a distance of eighteen or twenty miles above and below the city. It required another hundred years to extend the levees up to the mouth of Red River, some two hundred miles above New Orleans, though by that time, 1828, there existed some disconnected and unfinished levees on the west bank of the Mississippi as far up as the mouth of the Arkansas, and some progress had been made in levee building on the Upper Lafourche, then one of the outlets of the Mississippi River.

The richness of these alluvial lands had attracted quite a large population, and the levees were rapidly extended. Between 1861 and 1865, neglect and the ravages of the Civil War destroyed the greater part of this work, but with the return of peace it was promptly taken up again, and has ever since been prosecuted with more or less vigor.

All of the earlier levees were so small and low as to be frequently overtopped and broken by the floods. Their proportions, compared with those of the levees of to-day, appear almost absurdly insignificant. As late as 1851 the levees between New Orleans and Red River Landing, from actual measurements made by the United States Delta Survey, were found to have an

average height of only 4½ ft., the largest not exceeding 8 ft. in height nor 32 ft. in width of base.

From these small beginnings the levee system of the Lower Mississippi has been evolved to its present condition, and its future evolution seems destined to continue until the Lower Mississippi from Cairo to the Head of the Passes will have its embankment so broad and high, and the waters of the Greater Mississippi will be carried safely to the sea.

It is impossible to state what has been the cost of levees since their incipiency; in the state of Louisiana and that part of Arkansas affecting Louisiana, since 1865 up to date, some 225-000 000 cu. yd. of earth have been placed in the levees, at a cost of $50 000 000, 75 per cent. of which was paid by the state and organized levee districts, and 25 per cent. by the United States government.

It is estimated that it would cost, to complete the entire line from the head of the St. Francis Basin to the head of the Passes, at a grade sufficiently high and strong to afford complete protection against floods at the highest probable stages, the sum of $32 000 000, and for the protection of the same against the encroachment of the river from the caving of its banks, some $12 000 000 more.

Crevasses and inundations, resulting in extensive loss of property, are liable to occur during all floods so long as the system is incomplete. The increasing strength of the levees will be best understood by a comparison of the loss inflicted upon them by previous floods. In 1882 the total number of crevasses in the levees was 284, aggregating 56.09 miles in width; two thirds of the entire valley was practically inundated. In 1883 the number of crevasses was 224, with an aggregate width of 34.1 miles. In 1884 the crevasses numbered 204, aggregating 10.64 miles in width. In 1890 the total number of crevasses was 23, aggregating 4¼ miles in width. In 1897 there were 38 crevasses, whose combined width was about 9.1 miles. In 1903, when the flood, in some places, reached stages as much as 3 ft. higher than any previously known, there were six crevasses, aggregating 2½ miles in width, or about one sixth of one per cent. of the entire levee lines with a length of 1 470 miles, overflowing about 3 000 sq. miles out of 25 000, which showed an efficiency of 80 per cent. In 1908, with a flood as great as in 1903, there were few breaks in the levees, and with very much less territory overflowed, whilst the record of the recent flood has shown to have exceeded that of any previous high water as follows:

Name of Gage Station.	Elev. of Zero Gage Cairo Dat.	Highest Water of Record Previous to 1912.		High Water, 1912.	Difference, Feet.	Estimated Ultimate High Water M. R. C.	Provisional Grade M. R. C.
Cairo	290.84	1883	52.20	54.00	+1.8	54.17	56.17
Memphis	203.97	1907	40.30	44.90	+4.6	41.60	43.60
Helena	161.98	1897	51.75	54.30	+2.55	54.10	56.10
Mouth White River	128.73	1903	53.70	56.30	+2.6	56.40	58.40
Arkansas City	116.44	1903	52.90	55.40	+2.5	56.30	58.30
Greenville	108.00	1903	49.10	50.50	+1.4	50.50	54.60
Lake Providence	89.62	1903	46.48	48.25	+1.77	48.00	51.00
Vicksburg	66.04	1897	52.48	51.90	−0.58	55.05	57.00
St. Joseph	52.74	1903	48.07	48.60	+0.53	50.80	52.80
Natchez	36.89	1903	50.35	51.40	+1.05	54.00	56.00
Red River Landing	23.85	1897	50.20	53.20	+3.00	52.50	54.50
Bayou Sara	23.95	1897	43.70	47.20	+3.50	45.70	47.70
Baton Rouge	20.06	1897	40.65	43.80	+3.15	43.20	45.20
Plaquemine	21.06	1897	36.25	39.74	+3.49	38.70	40.70
Donaldsonville	19.48	1897	32.75	34.80	+2.05	34.95	36.95
College Point	21.24	1897	27.95	30.18	+2.23	29.80	31.80
Carrollton	20.91	1893	19.42	20.70	+1.28	20.35	23.35
Fort Jackson	19.26	1897	8.30	8.50	+0.2	8.00	10.50

It did not reach at these points the provisional grade as established by the Mississippi River Commission. Of the area protected by levees in the state of Louisiana, some 20 per cent. has been overflowed by the existing crevasses, which is about 6 per cent. of the total area of the state.

The Mississippi River Commission was created by an act of Congress, approved June 28, 1879. The act provides that it shall consist of seven members, of whom three were to be from the Engineer Corps of the Army, one from the Coast and Geodetic Survey, and three from civil life, of whom two were to be civil engineers by profession. Its duties are defined in part as follows:

"To take into consideration and mature such plan or plans and estimates as will correct, permanently locate and deepen the channel, and protect the banks of the Mississippi River; improve and give safety and ease to the navigation thereof; prevent destructive floods; promote and facilitate commerce, trade and the postal service."

Prior to 1882, the United States government contributed nothing to levee protection. After the great flood of 1882, the Mississippi River Commission allotted money to levee building under the theory that in order to obtain and maintain deep, low water navigation, a confinement of the waters within the banks by levees was necessary; and, for many years following, the amount spent by the government on levees was limited to such stretches as were deemed by the River Commission as falling under the above consideration. No money, however, could be used for the express purpose of affording protection from overflow. Some twelve or thirteen years ago Congress removed this objectionable provision from the Rivers and Harbors Bill, and since then the Mississippi River Commission has made annual allotments to the several levee districts for levees, for the purpose of giving protection from overflow, and has expended some $13-000 000 on the levees in the state of Louisiana.

Of the 1 496 miles of levees on the Mississippi River, some 778 miles are in the state of Louisiana and 72 miles in Arkansas (Chicot and Desha counties), which protect the state of Louisiana. A most recent statement, compiled in the office of the Board of State Engineers, makes the number of cubic yards of levee work in Louisiana, and that part of Arkansas affecting Louisiana, contracted under each administration, from 1865 to April 20, 1912, to be in round numbers as follows:

	Cubic Yards.	Cost.
By the state	73 250 000	$20 400 000
By the district	80 500 000	16 000 000
By the United States government	70 000 000	13 000 000
Total	223 750 000	$49 400 000

The alluvial valley subject to overflow, and protected by levees, has been subdivided into levee districts, organized under the various state laws, and managed and operated by boards of commissioners. In the state of Louisiana there are some seventeen districts. The first to be organized in this state is:

1. The Fifth Louisiana Levee District, by Act No. 44 of 1886.

The Board of Levee Commissioners of the Orleans Levee District was created by Act 93 of the General Assembly of the state of Louisiana, approved July 7, 1890. Under the provisions of this act, the Parish of Orleans was "formed into a Public Levee District," and a Board of Levee Commissioners, composed of nine persons possessing all the requisites of a qualified elector in said parish, administer the affairs of the district, seven of whom are appointed by the governor of the state from the several municipal districts of the city, and two (the Mayor and the Commissioner of Public Works of the City of New Orleans) being *ex-officio* members of the board.

The said Board of Levee Commissioners is charged with the construction and repairs and invested with the control and maintenance of all levees in the said Orleans District, whether on river, lake, canal or elsewhere. The said Board of Levee Commissioners, as to location, construction and repairs of all levees on the river front of said District, shall first have the approval in writing of the State Board of Engineers.

Length of Levee Lines.

The public levee lines of the district lie on both sides of the Mississippi River, that on the left or east bank being 12.09 miles, and that on the right or west bank 13.63 miles in length. The district also maintains lines of "Rear Protection Levee" aggregating about 46.8 miles in length.

Grades of Levees.

Of the 12.09 miles of levee on the left or east bank, 5.32 miles, or 44 per cent., of the line is 4 to 5 ft. above the high water, 1903; 3.85 miles, or 31.8 per cent., is 3 to 4 ft.; 1.62 miles, or 13.4 per cent., is 2 to 3 ft.; and 1.3 miles, or 10.8 per cent., is 1 to 2 ft.

Of the 13.63 miles on the right or west bank, 1.9 miles, or 14 per cent., of the line, is 4 to 5 ft. above the high water of 1903; 0.96 miles, or 7 per cent., is 3 to 4 ft.; 5.22 miles, or 38 per cent., 2 to 3 ft.; 4.85 miles, or 36 per cent., is 1 to 2 ft.; 0.7 miles, or 5 per cent., is 1 ft.

In consequence of the low grades and other defects of a more or less serious character, here and there, the Orleans Levee District, in response to public demand, some five years ago, inaugurated a movement to improve and maintain as rapidly as possible its levee lines along the Mississippi River to the grades and sections as recommended at that time by the Board of State Engineers.

Formula of the Board of State Engineers.

In general terms, this formula proposed an embankment of earth to be built and maintained to a grade not less than 5 ft. above the high water of 1903, with a crown not less than 50 ft. wide, river side slope not steeper than 3 horizontal to 1 vertical; and land side slope not steeper than 10 horizontal to 1 vertical; the flattening of slopes and widening of crown beyond these limits to be governed by the special requirements of what is known as the "Commercial Front," on the left or east bank of the river. On the right or west bank of the river the levees to be raised and enlarged to a grade 5 ft. above the high water of 1903, with crown 10 ft. wide; river side slope not steeper than 3 horizontal to 1 vertical, and land side slope not steeper than 4 horizontal to 1 vertical.

Provision of Funds.

To carry out this project necessarily involved a large outlay of money for payment for property appropriated. Since the inauguration of the movement, on June 4, 1907, brought about through a conference of the commercial exchanges of the city, with the Hon. N. C. Blanchard, then governor of the state, the mayor and others, to improve and maintain the line of levees along the Mississippi River, protecting the city of New Orleans from overflow, as rapidly as practicable, and to the extent of all available funds derived for this purpose, some $4 523 078.79 have been expended up to date, which amount is divided as follows:

First: Contract work undertaken in construction, and enlargement of certain stretches of the levee line on the Mississippi River, amounting to 1 668 718.5 cu. yd. of earth, and 1 264 145 ft. of creosoted revetment, at a cost of $994 971.28, which includes

also $8 612.44 for the demolition of the H. T. Lawler Milling & Trading Co., Ltd., Concrete Flour Mill.

Second: Maintenance, repair and operating expenses, approximating $361 478.09; interest on bonds, approximating $543 300.00; and some $2 623 329.42 have been paid out for the purchase of property, which includes some $415 447.73 of outstanding certificates issued for appropriaton of property, bearing 5 per cent. interest; so far averaging, as shown by the work undertaken since the incipiency of the project, nearly three times as much as the cost of the levee work itself.

The district appealed to the General Assembly of the state of Louisiana in 1908, and succeeded in having its previous bonded indebtedness of $500 000 increased to $3 000 000; this amount is outstanding. The other sources of revenue are the district tax authorized and permitted by law, which is an annual *ad valorem* tax of one mill on the dollar on all property subject to taxation in the district, and the annual allotment by the state of $10 000 from the General Engineer Fund. The assessed valuation of the district, on the tax rolls of 1910 and 1911, was $231 045 937 and $233 383 437, respectively.

Future Work.

Whilst the levees have been very much improved since the high water of 1908, considerable work yet remains to be done to bring the line up to grade and section as recommended by the Board of State Engineers, as shown in detailed attached statements, approximately at 2 296 200 cu. yd., divided as follows:

Orleans Parish, left bank	1 635 000
Orleans Parish, right bank	661 200

Whilst from these statements it would appear on the surface to be quite an undertaking, and involving a large expenditure of money to complete this project of enlargement of the system of levees on the east bank of the river, the handling of earthwork by the use of mechanical devices has reduced the cost of actual levee work over 50 per cent. from what it was in the incipiency of the project in 1907. As we progress in our work we are getting ahead of the commercial front of the city, and the value of property to be appropriated (which in the past has taken over three times the amount of money spent on actual construction work) will not in the future consume so heavily the revenues derived for this purpose. This, however, is based on a conjecture that the banks of the river will remain permanent.

Bank Protection.

The urgency of the character of work required to protect the banks from caving, and to fix the harbor lines in the Port of New Orleans, has long been admitted by the United States government, and considerable work has been accomplished through appeals to the government by her commercial bodies and others.

Since its incipiency in 1878, the United States government has expended some $2 000 000 in revetment of the banks with subaqueous mattress work, of which sum some $707 000 has been expended since 1907, the inauguration of the project of enlarged levees by the Orleans Levee District.

The Board of Levee Commissioners of the Orleans Levee District has repeatedly announced that if the national government will undertake the task of bank protection, and fix the harbor lines, the district will construct and maintain all the levee lines required.

SHOULD THE FEDERAL GOVERNMENT NOW ASSIST IN THE CONTROL OF THE LEVEE SYSTEM?

By Frank M. Kerr.

With so many subjects upon so many inviting fields of thought before us to-night, opportunity to do no more than, with a hop-skip-and-a-jump, touch upon the high spots of each, seems to me, within the space of this one sitting, possible. Hence, the following apology for a treatment of the subject allotted to me, namely, "Should the Federal Government Now Assist in the Control of the Levee System?"

There does not appear to me to be any room for argument in regard to this question. Nor is it a new proposition, for the federal government has already for the past thirty years been, by degrees, materially assisting in the control of levees. Therefore, it is not a question of *now* assisting, but a patent, self-evident fact that the federal government not only *should* but *must* greatly improve upon the extent and scope of its assistance in the control of the levee system.

Up to the year 1882, memorable as a most disastrous flood year, the federal government took no active part in this class of

public improvement, that is, in the construction and maintenance of a system of levees in the Mississippi valley to protect from overflow. Its activities, more or less spasmodic, tentative and, comparatively speaking, aroused at intervals of time few and far between, were confined to river and harbor control. After the trying experience of 1882, however, on the plea, well taken and finally and fully recognized and accepted, that the construction and maintenance of a system of levees would aid in fixing the course of the river, and thereby contribute to the improvement of navigation, the federal government took its first step towards aiding in the control of the levee system. But for this aid from the federal government in 1882, it is a matter of grave doubt what would have been the fate of the levee system in Louisiana, if not in the Lower Mississippi Valley and all that so depends upon it, — life and property, and progress and prosperity, and the uplifting of a great valley and a great people.

The high water of 1882 left the levee system overtopped generally, breached in no less than three hundred places, the aggregate width of which was over sixty (60) miles, and the people of the state utterly disheartened and demoralized. The federal government, however, here came to the rescue, in a comparatively small way, it is true, but sufficiently to give the people new courage, and they once more put their shoulders to the wheel, and have kept it rolling ever since. What has followed? An increase in the length of the levee lines of the state from 1 025 miles in 1882 to 1 636.5 miles in 1912; an increase in the cubical contents of these lines of levee, with corresponding improvement in grade and section, from about 25 000 000 cu. yd. in 1882 to over 160 000 000 cu. yd. in 1912, representing in dollars and cents the sum of $49 100 591.60, of which the state of Louisiana and the levee districts of the state paid $36 344-136.33, and the federal government $12 756 815.27.

What did this accomplish? It has, the greater number of years, conducted, at extreme stages, past our doors, without even causing comment, the greatest floods known to the history of any valley. Has the investment proven profitable? In 1882 the assessed valuation of the state of Louisiana was but $197-417 125.14. In 1911 it was $546 820 340.00, three fifths of which enhancement in values occurred in the alluvial lands subject to overflow, and dependent upon levees. It occurs to me, and should, I think, to any one at all familiar with the problem, that this advance in the efficiency of our lines of defense against overflow is, to say the least, notable, and it could never have been

brought about except through the aid received from the federal government.

Now, as encouraging as this has been, it does *not* suffice. Experience has, beyond all question, shown us that levees, the greater number of times, even in their yet incomplete state, do insure immunity from overflow to the valley, and we have already done so much towards preparing them to meet the task imposed upon them, that we should not now hesitate to still further improve them. To now dally with other propositions, tangible only in speech and print, appears to me the height of folly. With money enough and system enough to fix our caving banks, build our levees somewhat higher and broader, and indulge in some refinements in the preparation of base, where known to be needed, and where burrowing animals are known to infest localities, — all matters of familiarity to the experienced levee engineer, — the solution of the problem is easily within our grasp.

We do not immediately possess the full resources ourselves, and, even if we did, it is generally recognized by the states at large that it is neither fair nor just that the whole burden of combating an invasion, for the source and advancement of which we are in no way responsible, should be imposed upon us. Aid must be had, and that aid, in the natural order of things, must come from the federal government. But it should come to us upon a direct, segregated basis, comprehending immediate expenditures for the accomplishment of practical results necessary to the protection of the valley from overflow, within a reasonable lapse of time, not coupled up with propositions, co-ordinate to some extent, but not necessary to the accomplishment of that which we, first and foremost, need ourselves, — levees. Any other course must, in my opinion, indefinitely defer, if it does not altogether defeat, our chances for aid.

It may be all very well for those interested in propositions far removed from our borders, to come amongst us and sing in dulcet tones that might, under most circumstances and conditions, tend to "soothe the savage breast, soften rocks, and bend the knotted oak," about conservation, reservoirs, power, irrigation, drainage, river control, and all that may follow in the wake of each combined, to be, in the dim and distant future, harnessed together into one grand vehicle of munificence and power, to convert our valley into an elysium of safety, progress and prosperity, but the federal government is slow, very, very slow, to be lured along such lines, all in a bunch, as it were, and

the effort must sooner or later prove abortive through the evidence of its own utter impracticability of accomplishment within any time profitable to the present generation.

The levee lines in Louisiana, as a general proposition, remain, after this high water, in a better condition than after any extreme high water of the past. They present to-day a far better foundation for improvement than ever before after any extreme high water of the past, and can, if operations be promptly and vigorously inaugurated and carried out, be, in less time than ever before, brought to a standard equal to the highest water of record, just as has been the policy of the past. To effect this, federal aid cannot too soon be secured and accorded. Federal aid and federal control, however, are two very different propositions. But this is not down upon the program for me to-night, and had best be reserved for another chapter, at some other time.

INCREASED WEALTH TO BE DERIVED FROM EFFICIENT CONTROL OF FLOOD WATERS OF THE MISSISSIPPI RIVER.

By George H. Davis.

The subject of Mississippi River flood protection, with recommendations relating to levees, revetments, channel improvement, forestation and reservoirs, have been most ably presented in the addresses of the evening.

I can suggest only in general outline the economics of this vast undertaking. The continental portion of the United States, for the purposes of this discussion, may be separated into three divisions:

(1) The section east of the Appalachian Mountain System, or Atlantic States.

(2) The section west of the Rocky Mountain System, or Pacific States.

(3) The section between the Appalachian and Rocky Mountain Systems, or the Mississippi Valley States.

The Mississippi valley states contain approximately 40 000-000 of the population and $50 000 000 000 of the wealth of the nation. There has been no equal area of land in the history of civilization which has contained so much natural and developed wealth as the Mississippi valley. The protection of this is far more important in every particular than the joining of the

commerce of the Atlantic and Pacific oceans through the Panama Canal, in which the United States has, in ship-ownership at least, but a comparatively insignificant interest. There never has been any proposed public work in the world's history that has exceeded in importance the development of the levee revetment and channel system from the mouth of the Mississippi River north, thus protecting the vast riparian lands of the states of Louisiana, Mississippi, Missouri, Arkansas, Tennessee, Kentucky and other adjoining the Mississippi River system. This system of rivers drains about 40 per cent. of the area of the United States, and its potential, tangible and intangible wealth probably exceeds the present combined wealth of all the civilized nations, amounting to about $500 000 000 000.

If the United States can spend $400 000 000 in the construction of the Panama Canal, on account of world commerce, it can well afford to spend an equal amount for the protection of the invested wealth of the Mississippi valley, owned principally by citizens of the United States.

The area subject to overflow is equivalent to 29 790 sq. miles. distributed by states as follows:

	Square Miles.
Louisiana	14 695
Mississippi	6 926
Arkansas	4 652
Missouri	2 874
Tennessee	453
Kentucky	125
Illinois	65

The complete financial interdependence of modern nations and sections through communication and trade causes a disaster to become both nation-wide and world-wide in its consequences.

Without complete physical protection or ample insurance, the flood burdens fall heaviest upon the immediate sufferers. In the period of 1785 to 1912 (one hundred and twenty-seven years) thirty floods in cycles of from five to eight years have occurred in the Mississippi valley. The records of the earlier floods contain no analyses of their business effects and the record of later floods furnish only approximate estimates. The various volumes of the *Congressional Record* since 1882, together with the official reports of the War Department and the Citizens' Commissions, furnish the most reliable information. A single agricultural parish of Louisiana in one year frequently loses in excess of $1 000 000. Mr. A. G. Durns states, in the "Standard

History of New Orleans," referring to the flood of 1882, that "according to the reports prepared by the police juries at the request of the governor, for the purpose of estimating the loss entailed upon Louisiana by the flood, it was shown that 28 out of 56 parishes were involved in it, the damage to crops of all kinds amounting to $11 408 000; that to stock, fences, houses and goods, levees and railroads, to $3 596 000, making a total of $15 004 000 lost in Louisiana alone. In Mississippi the loss was figured at $6 701 000; in Arkansas, at $4 033 000; in Tennessee and other states, at $1 300 000; the amount for all being $27 038 000." It is conservative to assume that each of these floods entailed local losses, as variously estimated, depending upon the property contained in the flooded areas at from $5 000 000 to $30 000 000, a probable total in the past century of more than $500 000 000. Could any section, except one of extreme natural wealth, remain supreme over such losses?

The intangible and indirect losses are in a sense incalculable. The whole wealth fabric of the world is built upon confidence, — confidence in nations, sections, structures, businesses and men.

The events which have particularly shaken the confidence of American and European investors and retarded the development of the great potential wealth of this section are the aftermaths of the Civil War, yellow fever epidemics and Mississippi River floods. The effects of the war have been discounted and are now and forever behind us. Under present government control, yellow fever will never again appear. The confidence of the world regarding health and climatic conditions has been completely and permanently established. There now remains but one great project in the accomplishment of which we shall merit the implicit confidence of the entire business world. Our particular need is not the disjointed action of individual states, but concerted action by the federal government, resulting in the complete maintenance of levees, revetments and channels, and their reconstruction where necessary. We are not asking sectional favors for the South in pleading for federal control of flood protection. The floods do not originate within our own borders, but come from three corners of the continent, merely passing our doors. There are thirty-one states in the Mississippi drainage area, seven of which have land subject to overflow. As previously noted, Louisiana, Mississippi, Arkansas and Missouri sustain the direct tangible flood losses. In addition there are many cities of other states on the river or its tributaries that bear heavy flood burdens. It is axiomatic that the lower valley

is worth saving, if not for us, then for its contribution to the financial strength of the nation. It is obvious that if about 40 per cent. of the national drainage causes the destruction of only 1 per cent. of its domains, it is a national affair. If war were in progress for the defense of this territory, would the forty-eight states of the Union sit idly by and allow Louisiana, Arkansas Missouri and Mississippi to fight their national battles? Why does the nation spend vast sums in the development of the arid sections of the West, where there is no developed wealth and far less potential value, and allow the state of Louisiana alone to pay more annually for flood protection from foreign water than the national government?

What are the specific losses resulting from uncertainty as to environment of investment? A doubtful section of country loses by migration its most progressive inhabitants to sections of greater certainty. The average income per family in the United States, considering both wealth and wages, is approximately $1 800 per annum. This is 6 per cent. annually on $30 000. Why have we not received a greater share in the migration from other sections and immigration from abroad? If from uncertainty we have lost or failed to acquire 200 000 families, or 1 000 000 inhabitants, the equivalent in money would be $6 000 000 000.

The recent passenger statistics of the trunk lines radiating from the Gulf States indicate that the South is acquiring by migration from the Middle West and other sections of the United States, as well as immigration from South Europe, between 350 000 and 450 000 residents per annum. This movement is the direct result of widespread confidence in our conditions. Confidence in the conservatism of our laws, confidence in the healthfulness of our climate, confidence in the fertility of our soil, confidence in our people, and finally, confidence in our freedom from disaster. From 1900 to 1911 the South increased its wealth $9 580 800 000, or 53.3 per cent. Do we want to see the tide turned?

From the high water period of 1903, when there were nine crevasses, to 1911, only one crevasse occurred. Never in the history of this section has business faith been so rapidly established. For nearly eight years a feeling of enthusiasm for Southern investments has not only pervaded our own country, but European money centers as well. The surplus capital of Europe, as well as our own, has been pouring into the South, and especially the southern half of the Mississippi valley.

The flood losses of 1912 have not as yet been computed. Whatever they are, they will be turned to profit. Not in a single fold, but a hundredfold.

The estimated total tangible wealth of Louisiana in 1911 was $1 400 000 000; of Mississippi, $990 000 000; of Arkansas, $950 000 000, and of Missouri, $4 500 000 000, a total of $7 840-000 000. Considering an average business, its intangible value, including its value as a going concern, with all that the term implies, should be equal to its physical value. The wealth of states consists of business in the collective, consequently it would be fair to assume a present value, tangible and intangible, of these states, of $15 680 000 000, equivalent to $114 per acre of land area. On the same basis the present tangible and intangible value of the whole continental United States is approximately $280 000 000 000, equivalent to $147 per acre of land area, a difference of $33 per acre. When a condition of confidence is established, at least 15 000 000 acres of land will be increased in value by nearly $500 000 000, while the total increased values due to migrations of both people and money to the states affected, based upon the values established in the country at large, will amount to at least $4 500 000 000. Increased values beyond these will be in direct proportion to the greater productivity of this section, as compared with the general average.

Without a handicap in its race for supremacy, what is the business future of the South? The present flood is not a great one as compared with those of the past, yet it has occurred at a moment when the friendly coöperation of the entire nation, through its investments in the South, is ours. The first five of the largest industrial corporations of the United States have in five years greatly extended their interests in steel, oil and land developments in the South. The railroads and other transportation companies have also extended their lines and services. The expansion of these businesses, with its resulting stock and bond distribution, has brought to our support a great body of investors, residing not only in the United States, but everywhere. With the pressure of earnest public sentiment insisting upon the safety of investment, the government will, based upon all precedent, assume the responsibility of Mississippi River flood control.

Regarding other public expenditures of the various cities, states and the nation in public works, which are now proposed or in progress, we may mention:

1.	The Panama Canal	$400 000 000
2.	The reclamation of arid lands of the West	100 000 000
3.	The New York State Barge Canal	100 000 000
4.	The New York City new water supply	175 000 000

There are hundreds of smaller undertakings in bridges, river and harbor work structures and tunnels which are being completed at public expense. Ample business returns on these great obligations should be assured, either directly or indirectly, to the government to warrant their assumption.

It is doubtful in the minds of some of the best economists whether the Panama Canal will return to the nation as a whole, or its citizens individually in the development of their various businesses, 4 per cent. annually. It may, however, to the general family of nations be a source of great profit, furnishing a corresponding increase in the world's composite wealth.

In the reclamation of arid lands there is again a question of ample return. The government has now spent over $60 000 000 and has reclaimed 1 000 000 acres. Arizona had a population in 1910 of only 204 354 and an estimated total developed wealth of approximately $150 000 000, yet the government has spent in the Salt River project, including the Roosevelt dam and the Gunnison tunnel, in excess of $8 000 000. If a similar per capita expenditure were made for river protection in the riparian states of the Mississippi valley subject to overflow, the total would be in excess of $500 000 000.

The limit of arid land irrigation in the United States is from 60 000 000 to 100 000 000 acres, contained in sixteen Western and Pacific Coast states. Drawing on every known feasible water supply, probably not to exceed half of this can be actually reclaimed, and its potential value would not exceed $3 000 000 000.

The New York state barge canal probably furnishes less return to the public or the state government than any undertaking now in progress. Regarding the water supply for New York City is an article by Walter McColloh, which may be quoted:

"The Water Supply Commission was created in 1905, the primary object of its creation being to insure an equitable apportionment of the sources for public water supplies among the various municipalities and other civil divisions of the state. . . . The most important of these cases is the enormous undertaking of the city of New York to acquire a new supply of water from the Catskill Mountains, amounting to 500 000 000 gal. per day to be delivered through a tunnel aqueduct ninety miles

long. The cost of this project is estimated at $175 000 000, or more."

This brief review of the present basis of appropriation in profit or return on public expenditure cannot fail to suggest the extraordinary comparative financial merit of the project we are urging. The voice of the 12 000 000 people affected in the first degree, the 28 000 000 affected in the second degree and the 52 000 000 affected in the third degree will be heard and heeded by Washington.

When this work is accomplished, the last possible barrier to Southern progress will be eliminated and the supremacy of this section will be finally and permanently established.

[NOTE. — Discussion of these papers is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 15, 1912, for publication in a subsequent number of the JOURNAL.]

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NEEDFUL CO-OPERATION OF ENGINEERS WITH UNDERWRITERS.

BY H. L. VORSE, MEMBER OF THE OREGON SOCIETY OF ENGINEERS.

[Read before the Society, May 16, 1912.]

UNDERWRITING is a science based upon the elemental principle of sharing a loss. Since it is security, or immunity from loss, that the assured seeks, it is apparent he cannot be asked to remunerate himself for loss sustained, but he is usually willing to coöperate with his guarantors in the reduction of their risk in order that he shall receive the greatest possible protection at the least possible cost.

Under press of modern methods it has been made necessary to establish rating bureaus which shall fix the rate on all insurable property, each within specified territories. To aid in an intelligent execution of this work, extensive laboratories are maintained by the National Board of Fire Underwriters, in Chicago, where it is the duty of the corps of engineers in charge to try out new devices of any and all descriptions that are calculated to in any degree curtail the hazard of a fire risk; this includes the many appliances which afford risks in themselves apart from their primary purposes, as well as those which have for their primary purposes the reducing of degree of risk. It has been said,

"There is probably no one institution in the country having greater authority in the field of applied electricity, nor, withal, of greater value and importance to the electrical industry as a whole, than are the Underwriters' Laboratories. The prestige of this institution has grown out of no legal statutes. The function of the laboratories is simply to make recommendations."

These laboratories were opened eleven years ago with one or two engineers in charge and supplied information to very few branch offices and rating bureaus. To-day there are about fifty engineers in charge of the work.

These laboratories are making exhaustive tests and reports of methods and materials at the rate of seven thousand a year. The result of all this systematized effort is the establishment of a "*code*," of which it may be said a statute is scarcely more effective in this particular field of action. The National Board of Fire Underwriters includes in its membership more than one hundred and seventy-five insurance companies, and these write more than ninety per cent. of all the insurance taken in this country. In the year 1910 this amounted to 36 billion 350 million dollars' liability assumed by these companies.

All cost attaching to such a system of protection is, of course, borne largely by the protected ones in the same way that a consumer pays the revenue tax on an imported or protected article. Is it not apparent, then, that the tax thus laid upon security against fire loss is an important matter? Shall the protection be maintained at so high a figure that only a few may directly enjoy it, or shall the cost be scaled down till all may avail themselves of its benefits to the fullest?

To cut the cost, the risk must be cut, and to do this effectively it is necessary to absolutely eliminate the fuel element. As a compromise measure when this is impossible of accomplishment, break up the fuel element in as small and as widely detached units as is possible. In Paris and Berlin this is so thoroughly well accomplished that those cities are absolutely immune from fire of the conflagration type. They won't burn as a whole — fire cannot travel there. History tells of the efforts of the Communists to burn Paris. The torch was applied everywhere, and the hose was cut, explosives were used, oil was thrown on, and the only result was that the insides of some structures were destroyed, but the fire element did not cause total loss because it could not travel. The San Francisco fire loss was about 350 millions, of which 135 millions were paid in insurance. Chicago, in 1871, lost 168 millions.

The Geological Survey estimates an annual loss — complete annihilation of one half the value of all buildings erected in the cities of this country for that year. Think of this enormous waste occurring year after year. To quote from Bulletin No. 418: "The actual fire waste due to the destruction of buildings and their contents amounted (1907, the last year for which

statistics are available) to $215 084 000, a per capita loss for the United States, $2.51." The per capita losses in the cities of six leading European countries amounted to but 33 cents, or about one eighth of the per capita loss sustained in the United States. Our lowest recorded annual loss was in 1878, and amounted to $64 265 000; in the following thirty years this amount increased 330 per cent. The national ash pile accumulated during these same thirty years represents a money value of more than 5 billion dollars, and if we include the cost of fighting fire in the same period, the figure becomes 8 billions. That is, about 17 per cent. of the nation's wealth created within the same period was destroyed absolutely without recompense in any form whatever; and this, too, is but one form of fire waste.

If we take the annual fire loss and add to this the excess cost of fire protection due to bad construction, and excess premiums over insurance paid, we have the grand total of $456 485-000, an annual tax which must be met by the property and non-property holders — the people of this country. This sum represents one of our questionable luxuries. It is a leak pure and simple. Considered comparatively, it is one half enough to defray the annual expense of our federal government. It is more than the total value of all gold, silver, copper and oil mined in this country during the year 1907. To come closer home, it is more than the total assessed valuation of taxable property in Oregon in 1907. It would have built four fleets of Russian ships like the two destroyed by the Japanese, or it would about dig and equip the Panama canal, — all this just one source of waste of property each year in this country.

I don't care especially for the big figures that represent dollars. The per cent. of efficiency is what I think appeals first to an engineer. After that is fixed, the dollars come or go as the case may be. I want to lay particular stress upon the absurdity of having to endure such methods as beget such results.

Now, by foreign countries we are badly beaten in some applications of coöperation. There they have reduced the per capita loss to considerably below 33 cents in many parts, as in densely populated cities, where the risk normally should be very great. Rigid, I might say severe, laws, vigorously enforced, have brought this result. Instance these laws in force in France.

"The tenant is responsible for a fire on his premises unless he can prove the fire was caused by something beyond his control, by some fault in building, or that the fire was communicated by a neighboring building."

"Every person is responsible and liable for any act of his by which any other person has or may have sustained any loss, damage or injury."

"Every person is responsible for any loss, damage or injury caused by his own act, carelessness or neglect."

These laws of France and the still more rigid laws of Germany show the spirit and purpose to have no loss if it is possible to prevent, and they certainly approach the limit for efficiency.

One of the agencies which might under certain conditions make a large contribution to fire loss is that of electrolysis.

One ampere of electric current flowing normally constant for one year will deposit 20 lb. of iron or 60 lb. of lead.

Think how this action upon a main supply iron pipe will affect fire risk. Is a great city at all safe and secure when supplied with water through an iron pipe that is located in the very path of these stray electric currents? Take, for example, our own city's pipe line extending in from Bull Run. The old pipe that was taken out in the last year or two was said to have been badly corroded and pitted. It would appear that little or no precaution has been taken to protect the new pipe. It is not too much to predict that within five to six years' time the new will begin breaking and soon the city will have to do the work over again. This pipe, in the ground, cost the city $1 306 000. It is bad enough to have to renew this item about three times in the period that should constitute its life under normal conditions, but what can the city rely upon for fire protection between the beginning of breakdown and the time of completed new construction? The city should take the same energetic precaution to insure delivery that it took to protect the source of supply, and that step should have been taken at the time the costly Bull Run pipe was put into the ground.

A very effective method for protecting metal pipe is the establishment of high conductivity return system frequently bonded to rail system. The rails should be thoroughly and amply bonded one to another with copper bonds.

There should be a limited allowable drop in the return copper system, and in addition to this all points on the pipe system showing electrically positive should be bonded by insulated copper wire to the main return system.

The destruction of pipe systems is not the only havoc wrought by electrolytic action of return or stray currents. The most modern Class A building is an easy prey. Instances of early deterioration and complete collapse of reinforced con-

crete buildings due to that agency are matters of history already, although we have scarcely begun building after that method.

I contend that any engineer, whether or not engaged in designing, installing, constructing or consulting, should thoroughly post himself concerning the business of the National Board of Fire Underwriters in this country and bear in mind that he should consult with similar organizations in foreign lands when his labors require that he go abroad.

America is said to be in a condition of social unrest. That is not saying the unrest means indecision. Great reforms are under way, but these do not include reform in fire waste; at least the tide of such a movement has not yet set in. It has been said of such a movement that all of the argument is on one side and, therefore, does not attract special attention.

It may seem a far cry to urge upon the engineer the necessity of weighing the probability of loss from lack of continuity of production traceable in many instances to flagrant disregard for well-established practice for fire protection. In many instances such inadvertence is nothing short of a crime, looked at sociologically, to say nothing of the direct waste of money values. What engineer does not figure factor of safety against breakdown of parts? Does every engineer figure factor of safety against loss by shutdown from fire? Let our engineers get the government idea. Build in a manner such as will reasonably insure indestructibility. It is said the Federal Government owns about $300 000 000 in buildings and is annually adding to this $20 000 000, while it carries no insurance at all. The annual premium would amount to $600 000 did it carry insurance. Let me tell you that this possible premium means an annual saving of 3 per cent. on the annual expenditure for new buildings or a cumulative 3 per cent. fund which each year after the twenty-third year will refund the annual twenty million dollar outlay for new buildings. There may or may not be anything new in this hint at the creation of a depreciation fund from what would otherwise have represented to the government fire waste, but that does not qualify the cold fact in the case. Twenty to twenty-five years is commonly taken as the life of a building, plant or other product of engineering skill, and such as come under the head of insurable properties may, in most instances in this country, be so improved upon in design, or materials, or location, or all of these points, that the refunding of depreciation account may be affected in the manner shown and still we

shall be behind other nations in the matter of curtailment of fire waste.

I am firmly of the opinion the profession should lend itself openly and vigorously to any well-directed effort having for its object the securing of legislation, municipal, state and federal, that will elevate the standard of requirement as measured against property loss from all causes.

The object of this paper is to show to those of you who may not be familiar with the purpose of the underwriter that you, the engineer, and the man or company that enlists your service, and the underwriter, these three, should work as a unit against the single element which lends itself to the production of faulty plan, poor materials, inferior workmanship, bad regulation, lack of supervision, etc. If it initiates one new thought here this evening, or quickens the mind of any of you, then it will not have been in vain.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 15, 1912, for publication in a subsequent number of the JOURNAL.]

FLOOD PROTECTION FOR MISSISSIPPI VALLEY.

DISCUSSION AT SECOND MEETING (JULY 8, 1912).

PRESIDENT D. S. ANDERSON. — We have invited here this evening, as a guest of the Society, a gentleman who will open the discussion for the other side, as it were. I take great pleasure in introducing to you Mr. George H. Maxwell, executive director of the Louisiana Reclamation Club, who will open the discussion of the papers read at the last meeting.

MR. MAXWELL. — *Mr. President and Members of the Society, Ladies and Gentlemen,* — I appreciate this courtesy very much, and more particularly so because I am not unmindful of the fact that the privileges of this floor have already been accorded to me by the Society some months ago, when, I think, I occupied your time about two hours on this subject.

First, it would probably be as well to state briefly what the issue really is between those who stand with the organizations that I represent and those who entertain different opinions.

I am very glad to see here, this evening, a map of the United States, because it gives us an opportunity of bringing out clearly to the minds of the audience the exact conditions involved in this discussion.

There can be no controversy between those who want the lower Mississippi valley developed with reference to the fact that as good a system of levees as human ingenuity can devise and money can build is needed from St. Louis to the Gulf of Mexico on both sides of the Mississippi River.

I want to make the position of the associations I represent so clear that there can be no misapprehension with reference to what it is our desire to do. I have stated it so often that it seems strange there could be any misunderstanding about it, but there are some, so I understand, who are under the impression we are advocating the building of reservoirs as a substitute for levees. That is not our position. I want that clearly understood. We urge reservoirs, not as a substitute for levees, but as an additional safeguard for protection against floods.

In reference to the proposed appropriation for levees and bank protection, the Ransdell Bill provides $11 000 000 a year for four years, or a total of $44 000 000, for building levees from

Cape Girardeau to the Gulf of Mexico. We are advocating an appropriation through the Newlands Bill of $100 000 000 for practically the same purpose from the Gulf of Mexico to Cape Girardeau, but that appropriation is spread over ten years' time. And more than that, our plan for this appropriation is that it shall be in addition to the appropriation in the Rivers and Harbors Bill, which has carried about $3 000 000 for levees, making $13 000 000 a year in all. We advocate $10 000 000 a year, plus whatever they may get from the Rivers and Harbors Bill, for levee construction on the lower Mississippi and for all other things necessary to make the system absolutely complete. Unless these facts are borne in mind, the real issue before the people of New Orleans and the lower Mississippi valley cannot be made clear to-night.

The advocates of "LEVEES ONLY" urge the people to go before Congress and ask for nothing more than leveeing the lower Mississippi valley for protection against floods, paying no heed to the fact that, in the 527 000 sq. miles drained by the Missouri River and over the entire drainage basin of the Ohio, there is a constant change going on for many years on the watersheds, and still going on, tending to make the floods more frequent — sweeping away the forests, draining the swamps, eating off the grass mat, which in old times covered that entire region and soaked the rainfall into the ground. Thousands of acres which in the time when Daniel Boone settled in Kentucky were swamps are to-day covered with tile-drained farms.

The northern half of Minnesota originally contained immense swamps; to-day there is some of the largest drainage machinery in the world at work draining the swamps of that state. What is the result? The water is no longer held back by the swamps. As soon as it falls it runs off into the river; and the consequence is what? That when that condition goes on over a million square miles, there is a constantly increased run-off, a higher flood crest ensues, with a constantly increasing volume of flood. In other parts of the world that has gone on to the final end. In China you find they are paying the penalty along the Yellow River for destroying the forests and doing nothing to protect the watershed from denudation and erosion. Their policy has been "LEVEES ONLY." The levees are constantly breaking and the river flows over the land, and the crops are destroyed, and thousands of people face starvation. Every time you read of famine in China, remember it is because they pay no attention to forest preservation or headwater control.

The reason they suffered in Mesopotamia the final destruction and depopulation of that valley was floods which they could not control. Did you ever stop to think that in the days of Alexander the Great he marched an army from the Hellespont to the Hydaspes and sustained his army on the food found from day to day on that march, and to-day an army would starve on that route?

Those changes are constantly going on. We contend that it is foolish for the people of the Mississippi valley to ignore those things. It is foolish for the people of the United States to ignore them.

What can be done immediately to restrain the formation of the great floods of the lower Mississippi valley at the point where the three upper tributaries converge? There may be differences of opinion as to how much of the flood water can be held back. The position we take is that it is demonstrated by facts that so large a portion of the possible flood of the lower Mississippi River can be held back that it is suicidal for the people of the lower valley blindly to refuse to assist in carrying out plans for headwater control. Every student of that subject realizes that this question of headwater control is a gradually increasing one; and when you start in to control a river every year will demonstrate more clearly what is necessary to be done. A river may be in time almost completely regulated, provided you adopt all the measures that can be adopted for that purpose.

The question is not whether you can store enough water on the upper rivers to stop the flood on the lower river. The point is that we should do everything that can be done. We advocate spending more money for levees than the advocates of "LEVEES ONLY," but we say you should not stop there and condemn the plans for headwater control without investigation. That is the attitude of those who condemn the reservoir system and the forestry system, systems that wherever they have been investigated have been demonstrated to be of tremendous effect in checking these floods.

In reference to the Ohio River, that drainage basin occupies 19 000 sq. miles. Until within the last four years the same dogmatic denial that any reservoir sites existed that could be utilized to check floods that destroyed property at Pittsburgh was iterated and reiterated. In 1907 they had a flood in Pittsburgh that did about $10 000 000 worth of damage, and they concluded it was time to get to work and do something. I refer to Pittsburgh, why? Because the Pittsburgh Flood Commission

Report covers 19 000 sq. miles of the drainage basin of the Ohio River; and, when that investigation has sustained every fact claimed for the reservoir policy, we say it does not lie in the mouth of any one to say it could not be developed in the same way on the lower tributaries of the Ohio River, and particularly the Cumberland and Tennessee.

The Flood Commission of Pittsburgh spent about $100 000 to investigate the matter. Now we know that seventeen of these reservoirs would lower the floods ten feet at Pittsburgh. You have the whole state of Virginia, Kentucky, Tennessee, part of Georgia and Alabama that drain into the Ohio River, through the Cumberland and Tennessee, which rise in the Appalachian Mountains. If the same proportion of area is applied to that lower country, there is absolutely no question of the fact that you can control the flood of the Ohio River at Cairo sufficiently to take off the crest of the flood and bring it below the danger line.

I do not hesitate to say that the people of this country do themselves an injustice if they assume an attitude of hostility to the plans for holding the flood water back in the Ohio River Basin in reservoirs in the upper valleys, instead of letting the flood come down and create their own reservoirs, as they did this year by overflowing your plantations.

Years ago Colonel Seddon proposed the permanent utilization of the St. Francis Basin as an impounding basin. Old Father Mississippi has done it himself this year. A reservoir one hundred miles long, fifty miles wide and seven feet deep it made for itself in the St. Francis Basin. The river went five feet higher at Memphis than ever before in the history of the country; and if the levees had held, and had been high enough to carry the water, it would have gone still another five feet higher. Those are the estimates made from careful investigations at Memphis. Three or four crevasses took off that surplus and stored it in the St. Francis Basin and other reservoirs the river made through the crevasses.

Pass now to the upper Mississippi. The Government of the United States has already built the largest reservoir in the world on the headwaters of the upper Mississippi, and it holds back a large amount of water. We absolutely know that in Minnesota and Wisconsin and Iowa there are multitudes of opportunities for storing water that eventually finds its way into the Mississippi River. Now, and in face of those facts, why should it be said that the government cannot go on and dupli-

cate this Winnebegoshish reservoir, and build a whole lot more of them and hold back more of the flood water? Why should the people of New Orleans say it is impracticable and cannot be done?

Now on the Missouri what do you find? You find one thing with reference to these floods, — that it is the combination of high water in more than one river that causes the flood. If you could remove the floods in the Missouri River you would go a long way to control the floods in the lower Mississippi valley. You take the Missouri River above Kansas City, and the water comes down from all this upper country here [indicating on map]. The valleys of Montana this year were flooded. The same with Nebraska. Thousands and thousands of dollars' worth of damage was done by the floods. Where did the water go? It did not evaporate. It came down to help increase the volume of your flood here. What can be done with that water? In the first place, Captain Chittenden made it clear that you can store in artificial reservoirs sufficient water to materially affect the lower river, provided you can control the Ohio. That we now know can be done.

You can go out on the Missouri River and you can take the water out of every western tributary above the Kaw River in Kansas, and soak it into the ground, and every acre of ground that you soak that water into will raise a crop of hay, and on a million acres it will raise ten million dollars' worth of hay. One year's crop of hay on the land you put two feet of water on will produce enough hay to cover the cost of the whole system.

There are few people who ever stop to think of the enormous quantity of water that soaks into the ground. When you talk of artificial reservoirs in the West instead of its soaking into the ground, you will get the comparison if you figure how much water the ground will hold if you saturate every acre with two feet. That is the same as twenty-four inches of rainfall. I do not speak from hearsay or from textbooks. I have traveled back and forth in that country until it is all as familiar to me as the state in which I was born. You can put two feet of water into the ground on ten million acres and you have taken 20 000 000 acre-feet of water, 31 250 sq. miles one foot deep. Now think how large that volume of water is. It is enough to make a flood from Cairo to the Gulf of Mexico three miles wide and ten feet deep! You cannot get away from those figures.

I have not the time to go into the details with reference to all these matters, but I can say there is not an objection that can

be raised to the plans for headwater control of the floods that I could not answer immediately if I had the time. When a man loses sight of the splendid constructive opportunities offered by that national policy and devotes his time to objections, he is not accomplishing much. I was impressed with something I read about Napoleon in the paper, last Sunday. Napoleon said he was entitled to no credit for crossing the Alps, but he was entitled to a great deal of credit for not believing the people who said he could not do it.

The artificial lakes proposed in the Chittenden report will store enough water to reduce the floods in the lower valley, but you can soak a much larger quantity of water into the arid plains. Where can you do it? I will tell you one place where you could divert the entire flood flow of a river out on to the arid land. The government has built a dam called the Pathfinder Dam, on the North Platte River in Wyoming, that blocks the canyon through which the dam runs and raises the water up level with the bench lands on either side. On both sides of the dam canals are built through which water is provided for irrigation, and consequently no more water is taken out than the river will supply every year for the farms, in all ordinary years. What becomes of the flood water? It runs over the dam and comes down here to increase the volume of your flood. Why cannot that flood water be stored in the sand plains of Nebraska? Of course it can. There is no question about that.

You come down into Colorado and what do you find? They have dried up the South Platte River in Colorado by irrigation and reservoirs. They dried up the Arkansas River the same way in Colorado at the Kansas line, and Kansas has been suing Colorado for the water.

I have gone into this subject with reference to what it is that we want to get done. Now, the next question is, How are we going to get it done? Let us assume for a moment that you are before Congress with your bill asking for an appropriation, say, of sixty million dollars, which I understand is the amount the advocates of "LEVEES ONLY" claim is necessary to be spent to complete the levee system. We propose to get a hundred million dollars for the same purpose. But let us say sixty million dollars for levees. You have to have a majority of the members of the House of Representatives to vote for the bill or you will not get it through. You go to the men up and down the Ohio River and you say, "Please vote for this bill." They say, "You have trouble down your way with water, so have we."

They ask, "How much damage does it do you?" You answer, "Well, some years we don't have as much trouble as others." "Oh!" they say, "we have ours every year, an average annual damage of fifty million dollars." I never quite understood why they wanted the water to come down here, but now I understand: they want it to come down so that you can train it to run!

The man in Louisville, the man in Cincinnati (where the Ohio rises and falls fifty feet), the man in Pittsburgh, has "some flood" himself, and he cannot understand why you insist upon letting the water run past him. He says, "We are reasonable about it; we are willing to take ten million dollars a year to stop the floods of the Ohio River and improve the sanitary conditions of the river; we think that is a good thing; and if we do hold back considerable of that water, it would be a good thing for you, but we are not asking Congress to do anything for us on that ground. We want Congress to do something to help us because of the benefits it will be to the Ohio valley. If you vote for us for ten million dollars we will vote for you for ten million dollars." That is a business proposition.

The population and the enormous aggregation of capital and industries from Cairo to the crest of the Appalachian Mountains are all interested, and yet the people down here reject the proposition and say, "We will have none of it." What is the result? You will not get a vote on the Ohio River above Cairo.

The regular flow of the Mississippi River is needed, for the navigation of the upper Mississippi is getting worse and worse every year, and the man higher up here [indicating on map] in Iowa, Wisconsin and Minnesota, says, "Yes, we have a reservoir in Minnesota; we want the water held back so that we shall have water to sail our boats in summertime, so that we shall have a navigable river, as we used to have. If you will vote for us, to give us five million dollars to help out conditions on our river, we will vote for you on the lower Mississippi River and for the people on the Ohio River, to prevent floods down below." "No," the man from here says; "we want none of the reservoir system; we want all that water down here; we want to train it to run."

Now, on the Missouri River, when you get out to the arid region, you will find they have a lot of Senators, two for each state, and all in favor of the West. They are friendly to you, but there is a lot of them who will figure, when you insist on having all the water of the Missouri River come down here to

make floods, that they need it very badly up there on their great arid plains, and they will not take kindly to the idea if you insist on having it come down here. They scratch their heads and say, "We will leave it alone; we will let you have the water, but we will not stand in with you to spend a lot of money on levees unless you will help us to get ten million dollars to hold back the floods on the Missouri."

It was suggested to me to-day, in conversation, that ten million dollars was not enough on the lower Mississippi. Ten million dollars each year for ten years is quite a large sum. Yet I would concede that, if this were not the fact, it is already known and demonstrated and made absolutely certain that at least a large proportion of the floods formed above Cairo under present conditions could be kept back and controlled on the upper Mississippi and Missouri and the Ohio rivers. I say that that fact is so absolutely demonstrated that it equalizes and enlarges this lower appropriation by giving you an added value because of the benefits you will receive from holding back the floods of the upper rivers, if our plan is carried out.

The only danger of not getting anything down here is that you will divide your forces between two plans and get neither. How can you get any large appropriation for "LEVEES ONLY"? I have tried to show you the difficulties when you go before Congress when you have no support except the lower Mississippi valley. That is a mighty little section of country to go before Congress for such an appropriation.

What is the other proposition? It contemplates an alliance of the territory of the whole Mississippi River and to the whole Missouri River, 527 000 sq. miles; from St. Louis to the crown of the continent, taking everything west to the Rockies and up to the Appalachians on the east. You make that combination and you have a force that nothing could stop. And the extraordinary aspect of conditions as they exist to-day is, that everybody is for that proposition except the people in the lower Mississippi valley, who need it the most. The whole Pacific Coast, the Associated Chambers of Commerce of the Pacific Coast, met last January and endorsed the proposition. The San Francisco Chamber of Commerce, the Los Angeles Chamber of Commerce, the Stockton River Regulation Commission, and many others all through the West, are for the proposition now. You are treating this proposition as though this combination was a new thing. I will give you a little history in regard to it, so you will understand how it comes about; and

when you are asking the people of the upper country to abandon their scheme for yours, you are asking for something, mind you, you are asking for something that cannot be done.

After a ten years' fight, the Appalachian Bill was passed a year ago last February, and for fear I may forget, I want to tell you one fact: I listened at the last meeting to a forestry paper by Professor Gregory, in which he referred to the Moore and Chittenden Forestry pamphlets. The same sort of a fight that has been precipitated here against the Newlands Bill was carried on for ten years against the Appalachian Bill. Every imaginable objection, constitutional, physical, financial, and every other that could be raised against the policy of the government taking hold of the headwaters of the river and regulating them from the source, was resorted to; and it terminated by the National Government coming in and acquiring these Forest Reserves. There is not any objection that was not made even to those in the Moore and Chittenden pamphlets, and yet, notwithstanding all that, the Appalachian Bill passed the Senate with only nine votes opposed. That shows what the Senators thought when they voted for the Appalachian Bill. That ought to dispose of those two reports as far as their effect on the headwater control of the Ohio is concerned. However, that is a diversion from my line of talk for the present moment.

The Newlands River Regulation Bill was introduced with the idea that it covered territory enough to get the votes necessary to pass it, but the real work of the campaign to secure its passage did not begin until after the surveys of the Flood Commission of Pittsburgh had been completed. On the first of December, I left Pittsburgh for the West to secure the support of the West for the bill.

You should bear in mind that Senator Newlands has been for years urging an appropriation of $50 000 000 a year for improving navigation, and doing in an adequate way what the government has been doing in a very inadequate way. There is a clause in his bill giving to the army engineers $24 000 000 from which to do all this work on the lower Mississippi, and $10-000 000 a year for the United States Reclamation Service, to build these reservoirs out here in the West [indicating on map] and on the headwaters of the Missouri River, and for doing other work that would have tended to alleviate the floods on the lower Mississippi valley. A large part of the $24 000 000 would have been spent by the army engineers in work between Cairo and the Gulf.

I came here to New Orleans in January. Shortly after that this great flood came. The disasters resulting from the flood made it manifest to every fair-minded man, every fair-minded thinking man, that the levee system which you, at least down here, had assumed was adequate, was totally inadequate; and the best proof was the inland ocean you had from Missouri to the Gulf, caused by the water flowing from the river through the crevasses.

Just as soon as the National Drainage Congress was over, we formulated our plans for a convention in New Orleans in November, which were published to the world more than three months ago. In this call it was specifically stated that it is proposed to nail down \$10 000 000 for the lower Mississippi, \$10 000 000 for the Ohio, \$10 000 000 for the Missouri Basin, and \$5 000 000 for Sacramento and San Joaquin valleys in California. That was the immediate conception of those who had planned the National Drainage Congress and the Louisiana Reclamation Club. The purpose was to broaden out the Newlands Bill to that extent and "nail down" that much money for this particular section of the country from Cairo to the Gulf.

Now, we say it does not make any difference what any individual idea may be as to whether or not you can hold back water in reservoirs. Enough facts are known, demonstrated by surveys on the ground, to justify the people of the Lower Mississippi valley in laying aside the "dog in the manger policy." That is the attitude you assume when you say, "We demand \$60 000 000 for 'LEVEES ONLY,' and you people on the upper rivers shall have nothing unless you can get it some other way than by a combination with us and by our votes."

All in the world that the associations I represent contend for is that the people of the whole Mississippi valley, from its source to its mouth, should unite and say that the government shall protect you not only by levees along the lower river, but shall also protect you from the formation of floods above Cairo. That is all there is to this question. Will you come before Congress with the support of forty-one per cent. of the entire territory embraced in the drainage basin of the Mississippi and Missouri and upper Mississippi, supplemented by the support of the whole West, or will you go before Congress with your little miserable handful of votes from southern Missouri, southern Illinois, western Kentucky, western Tennessee, Mississippi, Louisiana and Arkansas? It does not seem to me that there

can be much doubt as to where the people of the lower Mississippi valley will land when we get these facts before them.

My time is running short, and I have a paper here that I am going to read to-night, — something I rarely do, but I can cover the points I wish to make more quickly in that way.

The question under consideration by the Louisiana Engineering Society is: Shall the efforts of the people of Louisiana and New Orleans to secure national aid for relief against floods be limited to "LEVEES ONLY," or shall those efforts be directed towards securing the inauguration of a broad policy that will include *not only* an *adequate levee system* from St. Louis to the Gulf of Mexico, but also *all other measures* for flood prevention on the Ohio, Missouri and Mississippi rivers that will hold back as much as possible of the flood waters in the territory of their origin and thus lower the flood at Cairo and prevent the formation of floods that will devastate the lower valley?

Such measures for flood prevention by headwater control include all practicable methods of equalizing the flow of streams and providing for the beneficial use of the water for power, irrigation, farm and municipal supply, and navigation. They include forest preservation, water storage in natural and artificial reservoirs, and in the earth itself by irrigation works and flood water canals.

The entire flood flow of the Missouri River originating in the arid or semi-arid region can be absorbed into the sandy plains and dry bench lands of its drainage basin by a system of flood water canals, supplementing a system of surface reservoirs.

The crest of the floods of the upper Mississippi can be lowered below danger line at St. Louis by an extension of the reservoir system already begun by the National Government so as to include the entire drainage basin of that river.

The crest of the floods of the Ohio River can be lowered below the danger line at Cairo by an extension to all other tributaries of the Ohio of the reservoir system advocated by the Pittsburgh Flood Commission on the Allegheny and Monongahela rivers.

Were these measures of flood prevention taken on the three great tributaries that unite to form the Mississippi below Cairo, it would then be possible to construct a levee system that would through all the future years protect the lower Mississippi valley from floods.

If no measures are adopted to prevent forest destruction, denudation and erosion, or to check the sudden run-off, or to

prevent floods in the lower river by controlling them on the headwaters, it is only a question of time when the people of the lower Mississippi valley will suffer the fate of the people dwelling in the valley of the great Yellow River of China, or the plains of Mesopotomia where the country was finally destroyed and depopulated by uncontrolled floods.

This statement briefly outlines the position of those who contend that levees should be supplemented by headwater control and the regulation of the flow of the source streams and tributaries of the Mississippi River.

The batteries of the advocates of the "LEVÉES ONLY" policy have been trained chiefly on the plan for flood water storage in reservoirs. The grounds of their opposition have been often stated before, and are restated in the recent paper of Captain Sherrill before this Society (pp. 54–60, above). Time does not permit of more than a very brief reference to the errors into which the author of that paper has fallen, or into which it would tend to lead the public mind.

The first illustration from which argument is drawn in this paper is the Great Lakes, as to which it is said (p. 56):

"Now let us examine this Great Lake storage basin for some indication of the areas of reservoirs required to give this uniformity of flow at its outlet"—referring to the Niagara River.

It is shown that about one third of the area of the drainage basin of the Niagara River is covered by water surface of the Great Lakes. Then follows this statement (p. 56):

> "So, from this analogy, we might safely say that if we could control the entire rainfall of any basin and utilize one third of the area for the actual water surface, the problem would be perfectly solved. Obviously such a proposition is an impossibility; therefore a further examination is required to learn how much is the least artificial reservoir area that will give the needed protection."

Nowhere in this paper is the fundamental point clearly and fairly brought out that flood water storage to prevent destructive floods does not contemplate or necessitate storing enough water to equalize the flow of a river through the year, as the Great Lakes equalize the flow of the Niagara River, or the lava beds the flow of the Deschutes River. Protection from loss and damage by floods requires only that enough of the crest of the flood should be held back for a comparatively brief period until it can be allowed to flow down the channel in the wake of the flood without causing overflow or destroying property.

That is a very different proposition from equalizing the flow of the Ohio as that of the Niagara River is equalized by the Great Lakes, and the reference to the Niagara River as an illustration without full and fair explanation of the fundamental point above referred to creates a wrong impression in the minds of persons not specially familiar with the subject.

The question of the proportion of surface area necessary to be covered with water to afford flood protection on the Allegheny and Monongahela drainage basins is settled by the Pittsburgh Flood Commission report. The total area of that drainage basin is about 19 000 sq. miles. The forty-three reservoirs surveyed by the Commission controlled 11 833 sq. miles of that basin. The area submerged by the reservoirs would be only 43 920 *acres*, or 68⅝ sq. miles, — about one square mile out of every two hundred square miles of the drainage basin. And *seventeen* of those forty-three reservoirs would reduce the crest of the floods at Pittsburgh an average of ten feet and make the complete protection of that city possible.

All guesswork, speculation and surmise as to the area required for reservoirs must be laid aside in the face of these demonstrated facts. From facts known to-day there can be no doubt that a similar or larger reduction of the flood crest can be made on all the principal lower southern tributaries of the Ohio, and the time has come when those who oppose reservoirs should recognize known facts and cease exploiting theories based on mere assumption.

The paper of Captain Sherrill is full of other statements tending to mislead the casual hearer or reader. Referring to the Reservoir Report of Captain Chittenden, made to Congress in 1897, he says: "He did not consider the scheme practicable for flood control on the lower Mississippi."

"*It is probable, however, that in all the watershed of the Mississippi sites could be found that would insure a reduction of a flood discharge at Cairo like that of 1897 by one fifth of its maximum.*

"As already stated, the difficulty is not so much a physical as a financial one. To store, say, 500 000 000 000 cu. ft. of water, equivalent to 11 500 000 acre-feet, would cost, even at the rate of $5 per acre-foot, $57 500 000. This one fact condemns the project as a system for the *exclusive* purpose of flood prevention. But, whenever such reservoirs have other and more immediate purposes for their construction, the increment which each will form in the grand total necessary to produce some influence in the Mississippi floods is an element in its favor worthy of consideration."

Neither is $57 500 000 an amount so large as to be prohibitive, nor are the reservoirs to be built *exclusively* for flood protection, so both the objections suggested by Captain Chittenden are *obviated by conditions as they exist to-day.*

This is well expressed in the paragraph of the report of the Pittsburgh Flood Commission rejecting the plan for protecting the city by a wall, where the Commission said:

"If the objections to such a high wall were not so serious; if the fact that flood relief for Pittsburgh by a protection wall only would afford no flood relief except to Pittsburgh, leaving other river communities above and below to work out their own salvation, were ignored; if the headroom under low bridges, and the conditions affecting loading and unloading of river craft and governing future sewerage plans were not so notably improved by the reduction of flood heights; and if the increase of the low water flow that would be obtained by means of the storage reservoirs were not of such *tremendous importance and benefit* to navigation, sanitation, water supply and water power, the lower cost of the wall without reservoir control would recommend the adoption of that means of flood relief."

Captain Sherrill failed to refer to this positive rejection of the wall scheme, but said in his paper (p. 57):

"It was also found that with the assistance of a levee along the entire city front from 9 to 30 ft. high, averaging 14 ft., the city would be protected from overflow; or that a levee 10 to 47 ft. high, averaging 30 ft., would, without any reservoirs, prevent all of the flood damage at a considerably lower cost."

The conclusion drawn by Captain Sherrill from the Pittsburgh report is positively misleading. He says (p. 57):

"Assuming that the data secured by this Commission are correct, the question that naturally suggests itself is,—If it is necessary to hold back ALL OF THE WATERS FALLING ON 53.8 PER CENT. OF THE TOTAL DRAINAGE BASIN, assisted by a 14-ft. levee in order to protect a single city, ideally located for such protection by the reservoir system, at the foot of the mountainous area most available for reservoirs, how large an area must be controlled to prevent dangerous floods at and below Cairo with a drainage area above it on the three tributary streams of 908 130 sq. miles? It would be madness to assume a possibility of controlling the *entire rainfall* of more than 50 per cent. of this vast area, but even suppose one fifth of it, or 180 sq. miles, would be sufficient, then the reservoirs must control the rainfall of an area far larger than the entire mountain region drained by the Ohio and Missouri."

In the conclusion of the Pittsburgh Flood Commission on page 12 of the report, they say:

" 12. If the Seventeen Selected Projects above referred to had been in operation, without any wall, the storage of flood water in these reservoirs would have reduced all past Pittsburgh floods to below the danger mark, or 22-ft. stage, with the exception of the great flood of March, 1907, which would have been reduced from a stage of 35.5 ft. to a stage of 27.6 ft.

" 13. Supplementing the Seventeen Selected Projects by a wall along the low-lying portions of the river bank would confine all floods, *including a possible forty-foot flood*, within the river channels.

" 14. Flood prevention by storage reservoirs is possible and practicable, and is recommended because —

" (*a*) The flood relief would be extended over hundreds of miles of tributaries and of the main rivers, including the Ohio for many miles below Pittsburgh.

" (*b*) The impounded flood water, with proper manipulation of the reservoir system, would considerably increase the low-water flow of the tributaries and of the main rivers.

" (*c*) This increased low-water flow would greatly aid navigation and interstate commerce.

" (*d*) The increased low-water flow would notably improve the quality of the water for domestic and industrial purposes.

" (*e*) The sewerage problem of Pittsburgh and of many other communities along the rivers would be simplified.

" (*f*) The public health would be protected against the dangers arising from the unsanitary conditions caused by overflow and by extreme low water.

" (*g*) A considerable amount of water-power would be incidentally developed.

" 15. The solution of the flood problem therefore becomes of great importance to other communities along the river, and to the counties and the state, and also because of the benefits to navigation, to the National Government.

" 16. Reservoirs for flood control have been built in other countries, and have been so successful, both in preventing floods and improving the low-water flow and navigability of the rivers, that other large works of this kind are now under construction, and many more are contemplated."

Captain Sherrill leaves it to be inferred from his statement that a "*fourteen-foot levee*" is proposed along the entire river front, whereas the Commission does not refer to a levee at all but proposes a concrete or stone wall, costing only $667 200, along " the low-lying portions of the river bank." The cost of a wall *without reservoirs* would be $18 573 500, and this plan was rejected for the reasons stated by the Commission and above quoted.

Let us further analyze the statement of Captain Sherrill last above quoted. The total storage capacity of the entire 43 reservoirs surveyed by the Pittsburgh Flood Commission was 80 497 million cu. ft. A rainfall of 12 in. over that area would have made a total volume of 343 516 million cu. ft. The Commission expressly state, on page 156:

"The prevention of Pittsburgh floods by means of storage reservoirs does not necessitate the storage of the entire flood wave. The only part that must be held back is that rising above the danger mark, or stage where flood damage begins."

If the proportion of storage capacity and area submerged be carried on to the other tributaries of the Ohio, the total area submerged would be only about 400 sq. miles out of 908 130. The total storage capacity would be 3 823 000 million cu. ft., or more than seven times the amount estimated to be necessary by Captain Chittenden to reduce the floods below danger line at Cairo.

Instead of disproving the practicability of the reservoir system for flood prevention, the reference to Humphreys & Abbot proves its entire practicability. If $20 000 000 will store 80 000 million cu. ft. and lower the floods 10 ft. from a drainage area of 19 000 sq. miles, then $94 800 000 would store 379 200 million cu. ft. of water, and lower the floods below danger line at Cairo.

The associations I represent are advocating an appropriation through the Newlands River Regulation Bill of $100 000 000 for that purpose. We are glad to have our estimate confirmed by Humphreys & Abbot's report as to what it will accomplish. Of course, in 1858, $100 000 000 was a prohibitive cost. To-day it is no more than the amount of damage that has been caused by floods in a single year, in the Ohio River valley, and only twice the average annual damage every year.

The Leighton estimate of $125 000 000 is entirely within bounds, when it comes to measuring the cost of stopping such an enormous annual loss and damage. Captain Sherrill is unfortunate in his reference to Mr. Leighton's statement where he says (p. 58):

"As an indication of the inaccuracy of his determinations I will say that he found a storage capacity of 173 000 000 000 cu. ft. in 18 reservoirs on the Allegheny and Monongahela rivers, whereas the Pittsburgh Flood Commission was able to find only a capacity of 80 000 000 000 cu. ft. in 43 reservoirs, or less than

one half as much as the Leighton estimate in more than twice as many reservoirs. A subsequent and more thorough investigation has led to the conclusion that the cost estimated by Mr. Leighton should be increased to five or ten times his figures."

The fact is, that pages 139 to 154 of the Pittsburgh Flood Commission Report are devoted to "Streams upon which storage has not been considered," and the storage capacity of many of the reservoirs surveyed by the Commission could be enormously increased by raising the height of the dams. The Pittsburgh Report has been a splendid confirmation of Mr. Leighton's opinions. The reference by Captain Sherrill to Mr. Leighton's letter to Senator Ransdell was equally unfortunate. Nothing in that letter justifies the statement that Mr. Leighton "has receded from many of his former positions."

So far as the reservoirs' breaking is concerned, it is enough to say that, if the War Department engineers cannot build dams that will not burst, there are engineers in other departments of the National Government who can and will build them. I am quite willing to take chances with the War Department engineers, and I was mightily surprised to hear this objection raised by one of them. The Johnstown Dam was a mud bank. The Austin, Pa., Dam was notoriously unsafe. Such dams as the Arizona National Dam on Salt River, the Shoshone Dam, the Pathfinder Dam, the Wachusett Dam, the Ashokan Dam, the Hemet Dam, the Sweetwater Dam, the Assouan Dam on the Nile, are not going to burst. This objection seems almost puerile when urged against a policy that will prevent the recurrence of such a stupendous catastrophe as the great flood of 1912 in the Mississippi valley, with its heavy toll of death and devastation. At some future time I hope to have the opportunity of showing to this Society some of the many stereopticon slides that I have of the wonderful work Uncle Sam has done in the West in building dams for the storage of flood waters. These slides are now coming from Pittsburgh and should be here within a week or ten days.

No time remains for the discussion of the question of forestry as an influence on flood prevention. A word, however, should be said about the Chittenden and Morse pamphlets on forestry. They were filed as briefs in opposition to the Appalachian Bill, months before its passage by the Senate in February, 1911. Only nine Senators voted against that bill. That shows what the Senate thought of those papers. It is common-sense and common knowledge that forests conserve and regulate stream flow

and tend to check the sudden run-off that increases the frequency and volume of floods.

All I have to say in closing is this: The Newlands River Regulation Bill makes it possible for the government to begin immediately the building of levees from Cairo to the Gulf and the construction of reservoirs on the upper Mississippi, the construction of reservoirs on the upper Ohio, and it gives them the power to proceed and investigate every other possible site, and that must be done before the reservoir system can be condemned without actual surveys by anybody.

THE PRESIDENT. — In order that we may have a complete discussion of this subject this evening, we want to give everybody an opportunity to speak. In order to have the discussion well under way, we decided to put a number of gentlemen on the program and ask them to speak, after which the matter would be opened to discussion. I will ask Mr. Von Phul to take up the discussion.

MR. VON PHUL. — Mr. Maxwell has just given us a very fine political address, but I have been unable to see any facts directly relating to the engineering problem at issue that he has produced other than from the Pittsburgh Flood Commission. The political side of it is one which I did not take up, and I will, therefore, confine myself very largely to a review of what was brought out in the previous meetings.

The levees themselves which can be built to any proper section and height, must be properly placed and so located that their positions may be more or less permanent. The Mississippi River Commission and the State Engineers have told us how much money would be needed to accomplish the building of the levee. But what will be required to hold the banks of the river? Here we have the banks and revetment work necessary to make the location of the levee permanent, and it is particularly in this work that the help of the Federal Government has been needed. The Levee System to-day, in spite of the failure to which our attention has been called this year, has undoubtedly proved its value to be many times above the cost, of which about one fifth was paid by the Federal Government.

As to the scope of the levees and the aid the government should give, there can be no such question raised on the bank revetments. The upper Mississippi, the Ohio and the White rivers are not properly silt-bearing streams. The Missouri, the Arkansas and the Red are the main silt-bearing rivers. Keep the banks of the main river intact, and except for the discharge

of the Missouri, Arkansas and Red, we shall have a clear stream, probably, in the main river. The action of the Mississippi River can in no way be compared with that of the Yellow River of China, which has been held up to us as illustrating the terrible failure of levees to furnish protection. In contradiction of this I would like to read the following extract from "The Floods of the Mississippi River," by William Starling:

"The Hwang-Ho or Yellow River, of China, is also often cited as a proof that embanking rivers raises their beds. There is no analogy between the two cases. The Mississippi, in its alluvial part, runs between parallel ranges of hills, about 35 miles apart, by which its lateral excursions are limited. Of its three components, only one, and that the least, carries any large load of silt. The others, comprising three fourths of the whole, are clear-water streams. There is a superabundance of velocity, and power enough, not only to carry the burden of sediments to the sea, but also to take up more. The Yellow River, in its upper portions, is more like the upper Arkansas or Platte. It runs through sandy and arid lanes, decreasing rather than augmenting its volume of water, till it reaches the mountainous province of Shan-si, composed of carboniferous hills, capped with loess, which deflects the river to the south. From this point on, it receives several large and rapid affluents, heavily charged with loess. In fact, the loess formation is the prevailing feature of the geology of the country throughout the remainder of the course of the river through the uplands and even along the southern border of the Great Plain. It is as if the Ozark Mountains were composed of loess, in hills 2 000 ft. high, intersected with large and powerful streams, and as if the Arkansas after receiving the contributions of the yellow mud brought by these tributaries, should be turned into an almost limitless flat plain, to find or make its bed. If the river was fully loaded coming through the mountains, it will not be able to carry its burden after its descent to the plains, but must lay down a part of it, levees or no levees. It is not contended that confining a river will prevent altogether the silting-up of its bed, if such be the tendency of the river, to a marked degree, in its natural state. It is only affirmed that it has a favorable influence that way; and that if a river raises its bed when leveed it would raise it still more without levees."

The foregoing information about the Yellow River was derived mostly from Mr. J. G. W. Finjnje's "Memorandum on the Improvements of the Hwang-Ho," the "Hague," 1891, and from "Richthofen's Atlas of China"; also from General Wilson's book on China, and from General Comstock's "Memorandum," etc., previously quoted.

The engineers to-day, who have given the question of flood protection careful study, assure us, first, that levees can be made large and strong enough at a reasonable cost; second, that by bank revetments the stability of the banks of the Mississippi can be assured; third, that as one of the direct results of levees, the bed is not silted up, but deepened; fourth, that with a perfect system of levees, one that allowed no crevasse from Cairo to the Gulf, the height of the water, except perhaps between Memphis and Pittsburgh, would not exceed the stages reached this spring. To these reasons I think we may safely add a fifth: no other feasible plan has ever been proposed at a cost reasonable in either time or money that is capable of giving protection or relief in any appreciable degree. Outlets fail in silt-bearing streams; they were tried and condemned in Holland years ago, where the streams are not dissimilar to the Mississippi.

It is tedious to go over a subject so thoroughly covered, but there are some things that may still be pointed out, applying both to the reservoir system with irrigation and power development, and to the effect of forestation on floods. We all know that the drainage area of the Mississippi is 1 250 000 sq. miles, about 41 per cent. of the area of continental United States, but these figures really convey little to our minds. Look at the large map of the country prepared by the United States Survey. The yellow line boundary is the Mississippi valley drainage area. Look at the little area in Pennsylvania, Ohio, West Virginia and Virginia. That is the area proposed by the Pittsburgh Flood Commission to control the floods of the upper Ohio. Most probably it may, but it is impossible to conceive that such an area, five tenths of one per cent. of the total drainage area, can materially affect the flood water of the Mississippi.

The tables which I have examined in the report of the Commission show that at low water the effect of this reservoir here amounts to about three feet at Wheeling.

Mr. Maxwell referred to the five lakes at the head of the Mississippi River. In a paper read before the National Board of Trade, at Washington, by George H. Anderson, secretary of the Chamber of Commerce at Pittsburgh, which paper is embodied in the Pittsburgh Flood Commission's Report, Mr. Anderson said of reservoirs designed to improve the navigation of streams: "The most conspicuous example is a system constructed on the headwaters of the Mississippi by the United States Government. This undertaking was even sustained and

commended as tending to restrain the floods on the lower river, but this view was only held by the very thoughtless."

I think the total cost of the matter was a very little over one million dollars. Mr. Maxwell, in talking of the upper Mississippi River in relation to possible power development, stated, clear-cut, that it would not be necessary to supply stream reserve. I am familiar with a number of water-power developments in various parts of the country, and I know of no such development (with the exception of Niagara), where, in order to guarantee continuity of service, it is not necessary to provide a proper and sufficient stream reserve, thus furnishing a supplemental source of supply.

Here we have a map showing the elevation through the main Missouri valley. It has been shown that disastrous floods have occurred in the Missouri River affecting the waters in the Mississippi, which floods have originated below Sioux City. The larger portion of the Missouri valley, as you will note from the map, below Sioux City is from 1 000 to 2 000 ft. above sea level. How is it possible to take water from this portion of the river capable of furnishing disastrous floods and use it for irrigating bad lands to the northwest at an elevation of from 2 000 to 5 000 ft. above sea level?

MR. MAXWELL.—But does not a great deal of the rain fall on the higher elevation, which could be diverted on to the plains from the tributaries before it gets down to the main river?

MR. VON PHUL.— Certainly. If all of the run-off from the rainfall from that section of the country drained by the upper Missouri were used for the irrigation of that section, as you advocate, it would have little effect on lessening the floods of the lower Missouri or of benefiting navigation in low-water periods, and no effect whatever on the Mississippi.

The United States Government has to-day a thoroughly organized and efficient irrigation and reclamation service which has been doing most excellent work and stands ready to continue this work where the engineers of the service are in position to make definite recommendations.

Ignoring all incidental phases of this question of flood control, it appears, in my judgment, absolutely essential that we secure concerted action on the part of the various riparian states and cities, requesting the Federal Government to assist in the construction of levees and bank protection along the lines which the Engineer Corps of the United States Army, the Mississippi River Commission, the state engineers of the various riparian

states have prepared, and which, in the unanimous judgment of these men, are practicable, comparatively economical, and will ultimately be entirely adequate.

The discussion before the previous meeting of the Society was largely confined to the effect of reservoirs on the floods of the lower Mississippi River, and did not discuss the question as to whether, as a matter of policy, the people of the lower valley should approve the building of reservoirs for purposes for which they are admirably suited. I wish to make it clear that it is not my purpose to condemn reservoirs, or control of the headwaters of any of the tributaries of the Mississippi River for such purposes as advocated by the Pittsburgh Flood Commission, or the construction, under proper conditions, of reservoirs for irrigation or power development; but I believe it is both poor policy and misleading to request the people of the Mississippi valley to endorse a proposition which men, after devoting a great part of their lives to the study of the problem, recommend as impracticable and of little avail in accomplishing the control of the floods of the lower Mississippi valley.

The President. — I shall diverge slightly from the program of speakers and extend the courtesies of the floor to Capt. C. O. Sherrill.

Captain Sherrill. — I find that reports have a very good influence on this subject, so I brought a few along.

My paper, which was read two weeks ago, gave my views on this subject, so I only wish to call attention to a few of the remarks of my distinguished opponent here on the subject, Mr. Maxwell, in which he says that I misquoted certain documents. In the first place, he says that I should lead the ordinary reader to believe that I think it necessary, in order to carry out the excess flood water of the Mississippi River, to have such a storage basin as the Great Lakes. My intention was to show that storage basins are feasible, and I know of no better example of their feasibility than the Great Lakes. You have perfect regularity of stream flow there. Since you have not that, how much would it cost to get rid of the excess water at Cairo?

Mr. Maxwell also quotes Captain Chittenden as follows (and I am sure that Captain Chittenden would be very much pleased to see how earnestly he is quoted on both sides of this question): He did " not consider the scheme practicable for flood control of the lower Mississippi." Then he quotes Captain Chittenden to show that he does consider it feasible. " It is probable, however, that in all the watershed of the Mississippi sites could

be found that would insure a reduction of a flood discharge at Cairo, like that of 1897, by one fifth of its maximum."

Now, I do not consider that that is a very strong advocacy of the reservoir system. He says nothing about the cost, location, or anything of that kind. His final conclusion I will read. Captain Chittenden's report is not based entirely on the lower Mississippi, but was to determine the feasibility of reservoirs in the arid regions of the West, and he did believe that that was feasible. His final conclusion is, "The only direct and effective reservoir project, if any such be possible, for impounding floods of such vast magnitude as those of the Mississippi River, is that pointed out by Mr. Seddon in the second part of his memoirs." That is, the St. Francis Basin. He gave this to show the absolute impossibility of reservoirs controlling the floods of the Mississippi.

He also says:

"Few people have any adequate conception of either the origin or the magnitude of great floods like those on the lower Mississippi. It is a common error to think that they come largely from the melting snows in the mountains, and yet the floods of the Mississippi River come at a season when the flows from the mountains are very slow.

"In the greatest known flood of the Mississippi at St. Louis, — that in 1844, — a large part of which came from the Missouri, the latter stream was found by pilots to be in low water stage below Sioux City. On the occasion of the late stage of flood in the Mississippi, when the Arkansas carried no overflow, the flood did not run above two thousand feet per second at North Platte, Neb., and the upper Missouri and Yellowstone were both in the low-water stage."

This paragraph shows his opinion of what reservoirs on the upper Mississippi would be. Sioux City is not in this 2 000 to 5 000 ft. country given up here. [Indicating on map.] It is well down in the lower country.

What are your reservoirs going to do at the head waters for the protection of the flows down here? Suppose you put your reservoirs up in here [indicating on map], don't you see you have a vast area where the rainfall is greater all over it than it is in the mountains?

Take up Mr. Maxwell's statement in regard to the desirability. He said if you could raise ten million acres of hay, it would yield $100 000 000. But it would cost $40 an acre to put the water on that land. Forty times ten million is how much? — $400 000 000, and yet these advocates would have

you believe that all you have to do is to dig a little canal, and there you are. It is not feasible.

Why should you divide your energies when the sympathy of the whole country is with the Mississippi valley? Why should you divide your energies and spend a lot of money in other places where you do not think it will do any good, and where, in fact, you are reasonably assured it will not do any good?

I quoted in my paper what, by the way, is also in this large volume of Humphreys & Abbot, dated 1858, showing that the reservoir system was absolutely impracticable. Mr. Maxwell not only says it is practicable; to show us from this that it is quite possible, he says in his manuscript:

"Instead of disproving the practicability of reservoir systems for flood prevention, the reference to Humphreys & Abbot proves its entire practicability. If $20 000 000 will store 80 000 million cu. ft. and lower the floods ten feet from a drainage area of 19 000 sq. miles, then $94 800 000 would store 379 200 million cu. ft. of water, and lower the floods below danger line at Cairo."

Now, that is simply a proportion. If you could store out here a gallon of water for ten cents, and could store four gallons for forty cents under different conditions, it would be all right. If that were true, there would be nothing to say about the reservoir system. But here you have to store so many more gallons, by controlling 53.8 per cent. of the total drainage area above Pittsburgh; if you could control the same down here, you would reduce it at Cairo. Suppose you undertook to put a reservoir in the neighborhood of Louisville, — and you have had floods at Cairo and none at Cincinnati even, — suppose you put a reservoir in here [indicating on map], how much would it cost?

This manuscript also says, which Mr. Maxwell unfortunately had to admit, —

"Of course, in 1858, $100 000 000 was a prohibitive sum. To-day it is no more than the amount of damage that has been caused by floods in a single year in the Ohio River Valley, and only twice the average annual damage every year.

"Mr. Leighton's estimate of $125 000 000 is entirely within bounds, when it comes to measuring the cost of stopping such an enormous annual loss and damage."

That was the amount he said, if you could control the upper Mississippi, and I agree with that; if you could control the headwaters for $125 000 000, I would say that is the thing to do. The scheme is an admirable one in theory, if you do not consider cost.

Here is Mr. Leighton's report, and I hope you will pardon me for referring to these reports so often, but so many statements are made that I like to get to the original reports and read extracts from them. Reading from Mr. Leighton's report in the Report of Inland Waterways Commission:

"Selected reservoir sites in the Cumberland River Basin: Cumberland River, Williamsburg, Ky. Mean annual flow from catchment area, 190 second ft. Estimated cost of reservoirs, shown in proposed system, 52 reservoirs, with a capacity in millions of cubic feet, one to ten thousand: estimated cost $53 784 000."

That is, slightly over a million dollars apiece.

I have another interesting work, entitled, "The American Transportation Problem," by John Howe Payton. This book is published at fifty cents, and I would advise you all to get a copy. He analyzes the same thing, and being an engineer of considerable ability on the Louisville & Nashville, and assistant to the president of that railroad company, is entitled to some consideration. He states, —

"Total railroad mileage to be rebuilt, 78 miles. Seventy-eight miles of railroad built along the steep (sometimes perpendicular), rocky, mountain sides, crossing many creeks, flowing through wide-bottomed land that would, under the conditions, be converted into lakes and require steel bridges on masonry supports, would cost about $150 000 per mile, average, not including a bridge 90 ft. high, and about 3 500 ft. long, for the Cincinnati-Atlanta Division of the Louisville & Nashville Railroad, at Williamsburg, which would cost about $1 200 000. The whole territory adjacent to the proposed reservoir is underlaid with immensely valuable veins of coal, similar to coal lands in Pennsylvania, now selling for $1 000 per acre. By building cheap spurs from the existing railroads, all this territory can now be reached with inexpensive rail lines. If the territory were flooded, the existing railroad would have to be rebuilt high upon the mountain slopes on one side of each valley, and in order to obtain access to the coal on the other side of the waters, it would be necessary to build another line along the mountain slopes on the opposite side of each of the valleys, or else lose thousands of acres of coal at a time when Mr. Leighton tells us that the total supply is sufficient to last only seventy years, at the present rate of consumption. If Mr. Leighton be correct, this land will soon be worth $1 500 to $2 500 per acre. Perhaps it were better to estimate for an additional railroad along the opposite sides of each valley."

I won't read all of that. He goes on to say that the probable cost to the people of the nation would be $80 000 000; that is,

for one dam. That does not indicate that this opposition to reservoirs is entirely independent of investigation. Mr. Leighton said that 52 of these reservoirs could be built for about $53 000-000; this says that one would cost $80 000 000.

There are several other quotations here that Mr. Maxwell did not read. I want to read from Humphreys & Abbot's report. Reservoirs were not feasible when the country was sparsely populated. At that time, you could buy lands for ten cents an acre which to-day are worth from one to five thousand dollars per acre. Mr. Maxwell makes a distinction between reservoirs holding water the year round and that coming down with a flood. Which is easier, — to have the reservoirs so located as to catch the water in a flood within thirty days, or to catch it gradually in a whole year? "During the thirty-six days in 1858 from May 25 to June 29 inclusive, the total amount of water passing the latitude of Columbus exceeded by 648 172-800 000 cu. ft. that which would have resulted from a discharge per second of 1 050 000 cu. ft." Reservoirs situated above the mouth of the Ohio, and sufficient to have kept back in a single month fully 600 000 000 000 cu. ft. of water, would, therefore, have been essential to the security of the delta, if this system had been depended upon for restraining this flood.

I do not want it thought for a minute that everybody who opposes a certain line of legislation does it because he has some ulterior motive. This bill of Mr. Maxwell's provides that four of the members shall be army engineering officers, and they are to arrange for the distribution of the funds. There are two or three things in that bill that I think are impractical, and the reservoir proposition is one of them. A reservoir would be good in restraining floods at Cairo. But why divide your engineers? You know you have to have levees. Why branch off and spend a greater amount of money than is necessary to complete the levee system? The answer is, you want to get the one that will accomplish the work most quickly and economically. Now, the experts and the bureaus; why do they want the influence of the people down here? Mr. Maxwell said your influence does not amount to much. The people of the entire country are now interested in seeing the government protect you people down here, certainly to furnish part of the protection, and this sympathy is being utilized to get through some other things that have never been properly considered. How did you succeed in getting those planks for the protection of the lower Mississippi from the floods in the platforms at Baltimore and Chicago?

Mr. Maxwell criticises my remarks about the Pittsburgh Reservoir System, because I said these reservoirs would control 53.8 per cent. of the rainfall above Pittsburgh; I have that authority right here, which I will read: "These seventeen projects control 69 per cent. of the Allegheny Basin and 29.5 per cent. of the Monongahela Basin, or about 54 per cent. of the total drainage area above Pittsburgh."

It also goes on to say, as I quoted the other day, "In this diagram in which the projects are arranged from top to bottom in the order of effectiveness, the small decrease in flood gage height reduction, by the elimination of the fifteen projects, is indicated by the length of the dotted section at the bottom of the several columns." The average reduction effected by the fifteen projects is, approximately, only eight tenths of a foot, while the saving of cost, if they are omitted, is approximately $6 000 000, or 17.5 per cent. of the total cost of all the projects considered. The seventeen reservoirs they used were the only practicable ones that would give an adequate return on the money invested. This is the most authoritative book we have on the subject, and, therefore, I believe that everything they say in regard to Pittsburgh is true, although it has not been confirmed. They say that a more careful investigation may lead them to a change in their statement.

Suppose you have a flood reduction of 10 ft. at Pittsburgh; that does not mean it would be that below Pittsburgh. Just a short distance below, about 75 miles, at Wheeling, the Commission only claims 2½ to 3 ft. benefit at low water.

All investigations, to my mind, show that your money can be expended in better ways than in the construction of these reservoirs.

The President. — The most vigorous discussion on this interesting subject has been between two gentlemen who are our invited guests here this evening.

Mr. Maxwell has asked the privilege of reading to you about ten lines.

Mr. Maxwell. — I have the platform of the Democratic Party in my hand, and I now read from it:

"We renew the declaration in our last platform relating to the conservation of our natural resources and the development of our waterways. The present devastation of the lower Mississippi valley actuates the movement for the regulation of river flow by additional bank and levee protection below, and the diversion, storage, and control of the flood waters above, and

their utilization for beneficial purposes in the reclamation of arid and swamp lands and the development of water-power, instead of permitting the floods to continue, as heretofore, agents of destruction."

So you see, gentlemen, we have good Democratic gospel under our water-storage proposition.

THE PRESIDENT. — The subject is now open to general discussion. Any member of the Society, or any visitor who may desire, may make any remarks on the subject.

MR. DAVIS. — I have listened with very much pleasure to the address of Mr. Maxwell, who is our guest this evening, and I only wish I could speak as well as he has done. He is a remarkable speaker, and I have learned much from him, but I cannot agree with him when he says that we are narrow in our view of the situation. I do not feel that way, and I do not think any one member of this Society has that disposition.

We are not relying on the levees in the lower valley alone. We are not confining our interests to the lower valley either. I, personally, have an interest in Pittsburgh; many of my friends have vital interests there involving many millions of dollars; this is also true of other parts of the upper Mississippi valley. The money of a great many of my friends, and a little of my own money, is invested in Montana in irrigation, and also in Kansas City, where there are floods. In that city every bridge was torn down a few years ago, except one, due to floods, and the bottoms flooded. The only way to protect this property is to build levees.

As far as I can understand, the aim of the Society here is this: Do everything that can be done in any direction to protect the entire Mississippi valley, that is, the whole 1 250 000 sq. miles. The engineers of Louisiana know more regarding river control and water control than any other similar body. They spend their lives here, and have interests from Helena, Minneapolis and Pittsburgh down, and I want to say again, we have the strongest kind of regard for everything of benefit to this great section.

I am not going to attempt to summarize the papers read at the previous meeting, but I say that Mississippi River improvement is of more importance to us and the country than anything else, and I believe it is the consensus of opinion here, first, that this is the biggest work proposed at this time;

Second, that the Federal Government should assume control of it;

Third, that levees, revetments and channel enlargements are sufficient and adequate;

Fourth, that immediate execution of whatever is decided upon is imperative. We should have our levees completed to standard heights right off. We have gone eight or nine years without floods, and confidence in this section was being rapidly established, and we do not want anything to happen to destroy this confidence. I say we can control floods by levees, revetments and channel enlargements, and, as far as we know, this is the only way to do it.

I am in favor of irrigation, if we have the money, and I think it is an extremely important matter. Mr. Newell states somewhere that there are 100 000 000 acres of arid land which could possibly be irrigated. I personally feel that is a very large estimate. There are also 100 000 000 acres of swamp lands in the United States, principally in the South, and the swamp lands are very much more valuable than the arid lands of the West, where they raise one or two crops a year, while we raise three and four crops a year.

So it resolves itself into three things: first, river protection; second, swamp land reclamation; and, third, arid land irrigation. Only these three things, it seems to me, should be included in any bill.

In regard to the Newlands Bill, all we have is the last copy introduced in the House, May 7, 1912. I discussed this matter for a moment with Mr. Maxwell this afternoon. There are different amendments that might be added to this bill, but I do not know that any recommendations from any of us would be entertained, and yet I think that Mr. Maxwell's suggestions were fine: first, that we have at least ten million dollars per year for flood protection from St. Louis to the Gulf for ten years. I am glad to see the Ohio get ten million dollars, and the Mississippi five million, and the Missouri ten million. The Newlands Bill is indefinite and fails to locate expenditures, geographically. Under the bill, the entire expenditure of $24 000 000 in charge of the United States Engineering Corps could be made without touching the Mississippi River at all. I would like to see this expenditure pinned down. It will probably require years of congressional work before we get this bill through. The provisions of the bill rather disorganize the government bureaus, which are well established. We want to avail ourselves, of course, of anybody's knowledge in this matter, and it may or may not be wise to disorganize the departments now established.

In the Newlands Bill, there are six departments. The first is the Smithsonian Institution, one million dollars per annum; Bureau of Plant Industry, two million dollars per annum; Geological Survey, three million dollars per annum; Irrigation Service, ten million dollars per annum; Forestry Service, ten million dollars per annum; Corps of Engineers, United States Army, twenty-four million dollars per annum. Now, so far as the Mississippi valley is concerned, as I say, apart from this appropriation to the Corps of Engineers, United States Army, $24 000 000, there is nothing that could possibly apply to Mississippi River protection. The bill is dated May 7, 1912, and its provisions cover recent amendments. Now, so soon as they give us what we think we ought to have, we will recommend it. We should be pleased to see all the work provided for in the bill done. We hope that Ohio, Kentucky, Indiana and states bordering the Missouri will get what they want. As stated before, I think the Newlands Bill might be modified to have three departments instead of six, and in this form would appeal to all Senators and Representatives. The most important department is Mississippi Valley Protection, and for that we want ten million dollars per year at least. The next important provision should be swamp land reclamation, which can be reclaimed for twenty-five dollars an acre; while arid land irrigation costs twice that amount. Next we would be glad to see arid lands irrigated. These provisions are practical and businesslike.

Mr. Maxwell. — The proposed amendment to the Newlands Bill, I think, covers the point raised by Mr. Davis, as follows:

"*Provided*, that of said appropriation the sum of ten million dollars shall be annually expended for the construction of works such as those above specified, which may be built between the mouth of the Missouri River and the Gulf of Mexico for the control and regulation of the flow of the Mississippi River with a view to preventing the banks of the river from caving, and preventing overflow by means of levees, and permanently protecting and safeguarding the valley against floods, and to ultimately obtaining and maintaining a navigable channel from Cairo to the Gulf not less than two hundred and fifty feet in width, and nine feet in depth, at all stages of the year except when navigation is closed by ice."

In other words, the idea is simply to nail down ten million dollars on expenditures on the river between Cairo and the Gulf.

Mr. A. M. Shaw. — We have listened this evening to one of the most ardent advocates of the reservoir system; he discharges his heavy artillery. That this particular river needs regulation we will not attempt to dispute; and it is not in the province of a society like this to enter into matters of policy, expediency or general political combinations; so we will not enter into a discussion of all the points brought up in that connection. We will mention, however, a few points that were brought out. They claim the work proposed at Pittsburgh will materially assist the flood flow of the lower Mississippi River.

Mr. Maxwell. — I surely made no such claim as that; on the contrary, the report clearly states otherwise.

Mr. Shaw. — It was my impression that the proposed work at Pittsburgh would have considerable effect on the lower Ohio River. Assuming the work at Pittsburgh to be valuable, is it possible to assume, under the conditions that obtained in 1912, that if the reservoirs would be harmful to the high water at Cairo and above there, we should be benefited? The river stage at the time at Cairo was low. The interests of Pittsburgh would have called for a discharge of the reservoirs at the very time that it would be detrimental to the lower river. They claim that other areas of the Mississippi River can be protected, and it has been shown that this proportion would not hold. The rules of the rainfalls, as recorded, do not apply to the larger areas.

There is much in the reservoir idea to commend it to our attention, but the demands are so diverse, we are compelled to look to other plans for relief.

Upon looking back over the back files of technical papers, it is evident that the Pittsburgh project is larger than we have had in this country, or even in Europe. Take the Seine at Paris; no one has considered the possibility of reservoir plans being adapted to this river.

I have carefully considered this entire matter, and the few points that I have raised here have occurred to me simply in the discussions we have had here this evening.

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NOTES ON THE CONSTRUCTION OF THE CHARLES RIVER BRIDGE; EAST CAMBRIDGE EXTENSION OF THE BOSTON ELEVATED RAILWAY COMPANY.

BY CLARENCE T. FERNALD, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, September 18, 1912.]

THE following description of the construction of the Charles River Bridge for the Boston Elevated Railway Company attempts to show only the methods pursued, some of the difficulties encountered and the final result attained in its construction. The architectural details and design are not discussed and are but briefly referred to in this paper, although the credit for the conception and the skillfulness in design belongs to the architects, Messrs. Peabody & Stearns, and J. R. Worcester & Co., engineers, respectively. In the beginning perhaps a brief account of the early attempts to build bridges across the Charles River is not out of place, and I am indebted to Mr. Frederick H. Fay for the information.

Historical. — From the earliest colonial days the records graphically describe the efforts and achievements of the citizens of both Cambridge and Boston, in obtaining more convenient means of travel across the Charles River.

The first, or "Great Bridge," was built across the river about 1662, at the location of the Boylston Street or North Harvard Street bridge.

The first mention of any attempt to establish a public crossing of the Charles River at the site of the Boston Elevated Railway Company's bridge is made in a petition to the General

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Th[illegible] ...uity of concrete ex- [illegible] ...was decided to face the [illegible] ... two feet below mean low [illegible] ... above the finished grade of [illegible] above this last grade the [illegible]

Court, filed in June, 1738, by John Staniford *et al.*, of Boston, for liberty to construct a bridge from a point near the copper works in Boston to Colonel Phipp's farm (now East Cambridge). This petition was referred to the next General Court.

In February, 1785, Mr. Andrew Cabot asked the General Court to grant him leave to construct, at his own expense, a bridge over the Charles River from Lechemere's Point in Cambridge to Barton's Point in Boston. He was aided in this effort by a committee appointed by the town of Cambridge to appear and advocate his bill at the General Court; but the petition failed. Success was attained finally in 1808, when the Canal Bridge was incorporated by an act approved February 26, 1808. This act provided that the shares may be held, one third by individual proprietors of the Middlesex Canal Corporation, one third by individual proprietors of the Newburyport Turnpike Corporation, and one third by Andrew Craigie and his associates (among whom was Loammi Baldwin).

The bridge as originally completed and opened August 30, 1809, was about 2 796 ft. long and 40 ft. wide, with a draw 31.83 ft. wide (Nathaniel Shurtleff History of Boston, 1891). In 1846 this bridge was bought by the Hancock Free Bridge Company for $60 000.

By an act passed May 30, 1857, the proprietors were authorized to convey both bridges to the city of Cambridge, and on February 1, 1858, the Canal Bridge and West Boston Bridge were declared free public avenues.

Mr. Richard Hapgood, superintendent of tracks for the Boston Elevated Railway Company, and identified with the Cambridge Railroad from its inception, built the first street railway tracks across Craigie Bridge in 1861.

In 1870 the legislature passed an act transferring the care of the bridge to two commissioners, one to be chosen by Cambridge and one by Boston.

In 1903 the Charles River Basin Commission was created by the legislature and the bridge passed into the control of the Commonwealth. The old bridge (Fig. 29) was removed and the present Charles River dam constructed on its site, and upon the " downstream slope " of this dam is built the Charles River Bridge owned by the Boston Elevated Railway Company.

Legislation. — The numerous bills granting authority to build elevated railways in Boston date from 1890, and it was not until 1906 that an Act, Chapter 520, permitting the Boston Elevated Railway Company to construct the Cambridge Main

Street Subway and East Cambridge Extension, was passed and the following route fixed:

"*Section 21.* . . . . Between a point in or easterly of Lechemere Sq., in Cambridge, thence in and over said square and Bridge St., or private lands adjacent or near thereto, and over that part of the lands owned or leased by the Boston & Maine Railroad contiguous to Bridge St. and over Prison Point Street, . . . thence to and over the approaches to, if necessary, and the downstream slope and the waterway of the New Charles River dam now under construction in place of the Craigie Bridge."

In accordance with this last mentioned legislation the construction of bridge was begun.

Preparatory. — The base line and distances being adjusted, the center line of the bridge was finally established 30 ft. downstream from north face of coping of the dam, the south or upstream face of the Boston Elevated Railway Company's piers to be not less than 3 ft. distant from the same. It was further required that a separation joint should be left between the bridge piers and the wall of the dam.

Design. — The provisions of the Act required that the bridge, constructed on the downstream slope of the dam, in respect to its architectural features, should be subject to the approval of the Charles River Basin Commission, and for this reason the general design of the bridge was made by Messrs. Peabody & Stearns, architects for the company. There was also an advisory board of architects composed of Messrs. Chas. D. Maginnes, C. H. Blackall, R. A. Cram, Edmund M. Wheelwright, Chas. A. Coolidge and Robert S. Peabody, who passed upon the general features of the architectural design.

The original design contemplated a reinforced concrete structure with 13 piers, 11 spans, a solid floor with ballasted track, and a draw span having a bascule bridge of two leaves. The plan was changed later so as to provide a steel structure covered with concrete, crossing Prison Point Street, a single span for the bascule bridge, open floor with track stringers, and a change in the treatment of the finished concrete. (Fig. 1 and 28.)

On account of the failure in this vicinity of concrete exposed to the tidal action of salt water, it was decided to face the piers with granite from grade 98, i. e., two feet below mean low water, to grade 126.08, or five feet above the finished grade of the roadway on the dam. Above this last grade the super-

structure is of reinforced concrete made of crushed Chelmsford granite and granite dust.

The engineering features of the design were in charge of J. R. Worcester & Co., and all construction plans for the work were made by this firm, under the personal supervision of Mr. J. R. Worcester and Mr. George D. Brazer.

Construction.

In April, 1907, the condition of the work on the main ship lock, the boat lock and sluices of the Charles River Dam rendered it necessary to start work on the proposed Charles River Bridge, as it was intended to remove a portion of the footing course on the downstream side of the lock and sluices to permit the construction of the piers adjacent to these structures. Preliminary arrangements were made with the Charles River Basin Commission permitting the work to be done by the contractors for the dam, and on July 8, 1907, a contract was made with the Holbrook, Cabot & Rollins Corporation to construct the portions of piers 3, 4, 9 and 10 inside the existing cofferdams and adjoining the ship lock and sluices. The work of removing this footing course was begun July 31, 1907, at the ship lock.

From this time on, the work inside the cofferdams proceeded continuously, the concrete being in place to elevation 98 so far as possible by February, 1908, and the lower courses of stone laid, together with concrete backing, by the following April. (See Fig. 2.)

The next step was the removal of the cofferdams, completion of piers 3, 4, 9 and 10, and the construction of the five remaining river piers, viz., 2, 5, 6, 7 and 8, to elevation 126.08, or the top of the granite facing. The cut stone was furnished by the Boston Elevated Railway Company and supplied by the H. E. Fletcher Company, West Chelmsford, Mass., from their quarries at Chelmsford, delivered f. o. b. cars at the freight bridge just east of the site of the Charles River dam.

Dredging. — The borings indicated that the bed of the river at the site of the bridge had from 2 to 6 ft. of silt overlying a stratum of coarse gravel 4 to 6 ft. thick; below this was a layer of fairly stiff blue clay 15 ft. to 35 ft. thick, and again below this, in the channel of the river, a layer of soft blue clay 10 ft. to 25 ft. deep, which was directly on top of sand gravel and yellow clay mixed.

The Bay State Dredging Company were subcontractors for dredging piers 2, 5, 6, 7, 8 and portions of 3, 4, 9 and 10. The

FIG. 1. GENERAL VIEW LOOKING TOWARD CAMBRIDGE.

FIG. 2. FOUNDATION OF PIER 9, AT SLUICES, INSIDE OF COFFERDAM.

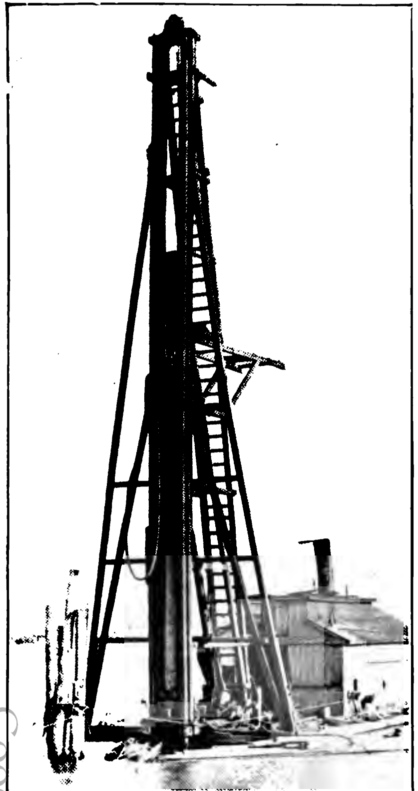

FIG. 4. FLOATING PILB DRIVER WITH EXTENSION GINS.

FIG. 5. "DOGS" HOLDING PILE IN PLACE.

FIG. 6. DRIVING SHEET-PILING FOR COFFERDAMS OF RIVER PIERS.

silt was removed to top of gravel stratum in all cases except pier 2, where the yellow clay mixed with sand and gravel was reached immediately below the marsh mud. The total quantity of material dredged was 18 986 yards.

Piling. — Immediately following the dredging operations the contractors began driving piles, which were of spruce with minimum butt of 10 in. and tip of 6 in. diameter. The piles were spaced 2 in. on centers in piers 3, 4, 9 and 10, and from 2 ft. 4 in. to 2 ft. 9 in. diagonally in remaining piers, and were driven through the gravel into the hard clay below from 25 to 40 feet; their bearing power was assumed at 11 tons each. (See Fig. 3.)

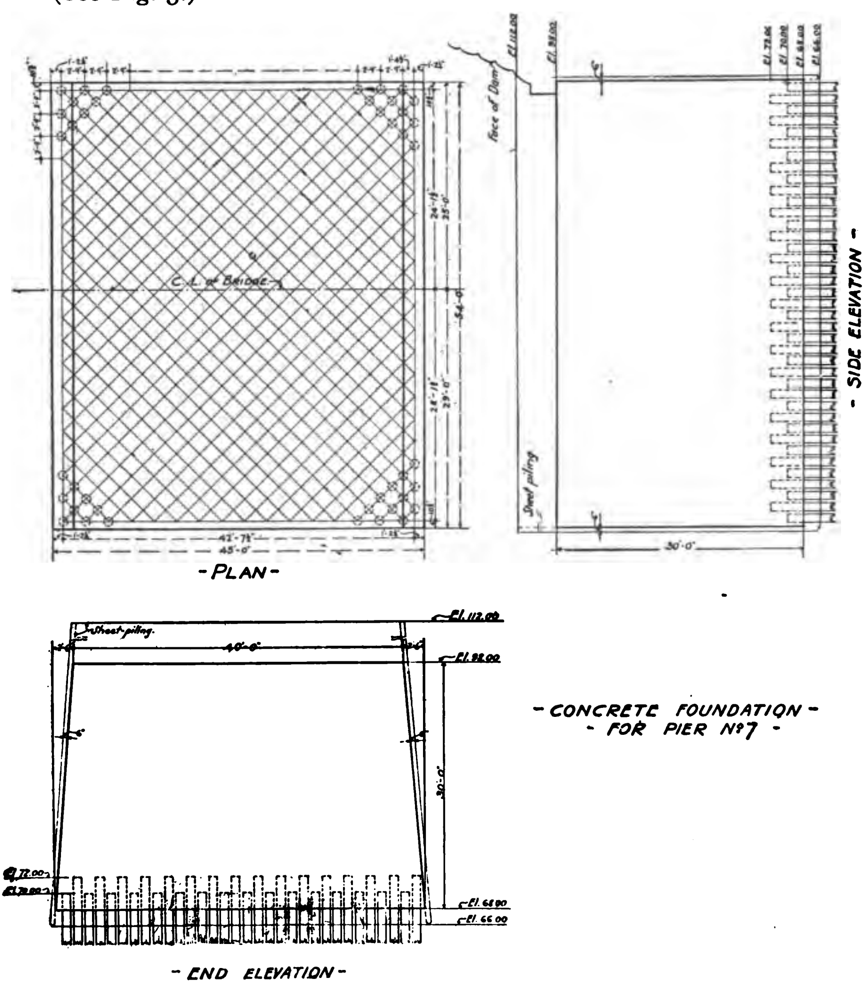

FIG. 3. TYPICAL PIER FOUNDATION SHOWING PILE SPACING.

The contractors' pile-driving plant was exceptionally efficient (see Fig. 4 and 5); it consisted of a large scow carrying a No. 1 Vulcan steam hammer of 36-in. stroke, mounted on extension gins, the entire dead weight resting on the pile being 15 000 lb. The gins were long enough to take a 75-ft. pile, and the extension guides would place the pile where desired in 40 ft. of water.

The tops of the piles were left at two different elevations in each pier, i. e., one row was left 2 ft. higher than the adjoining row, in a direction at right angles to the axis of the bridge. An allowance of 2 ft. was also made for the swelling or lifting of the bottom of the dredged area due to driving the piles.

Sheet Piling. — On the outside of each pier and marking its exact dimensions 6 in. tongued and grooved hard pine sheet piling was driven, varying from 25 ft. long in pier 2, to 50 ft. in piers 5 and 6. The end sections were driven plumb; but the sides, after being lightly driven, were pulled over to the desired batter and made fast by waling strips and tie rods. The tops of all the cofferdams thus formed were at grade 112. (Fig. 6.)

Concreting Foundations. — Upon completing the cofferdams and before concreting, the bottom of each pier was cleaned of all débris, and in the case of piers 6, 7 and 8 considerable sand or silt was removed in order to uncover the low piles so as to permit at least a 6 in. grip on the concrete.

The concrete (1:2:4) was mixed for the river piers in a 1-yd. cubical mixer, having a measuring hopper and screen overhead. The sand and stone were brought from Shirley Gut, dumped into the water at the mixer and rehandled into the screen by a derrick. The mixed concrete was dumped into the buckets, placed on cars running on a trestle in front of the piers and directly under the mixer; it was distributed where needed to traveler derricks at each pier and so placed in the foundations. The last 2 ft. of concrete were laid in the dry, the cofferdams being pumped out to grade 96. (See Fig. 7.)

All of the concrete was deposited under water by means of self-dumping bottom outlet buckets. (See Fig. 8.) The buckets were filled to the top and lowered gently into place, working from the outer edge, or next to the sheeting, in concentric rings entirely around the pier. By this means what laitance formed was forced to the center of the pier, and before concreting was commenced for another day the top of the work was scored by dragging a bundle of chains over it to stir up the sediment, endeavoring to secure a better bond. Fig. 7 shows appearance of

Fig. 7. Surface of Concrete laid under water.
At right a Pocket of Laitance Cut Away.
At left New Concrete being placed to Grade 98.

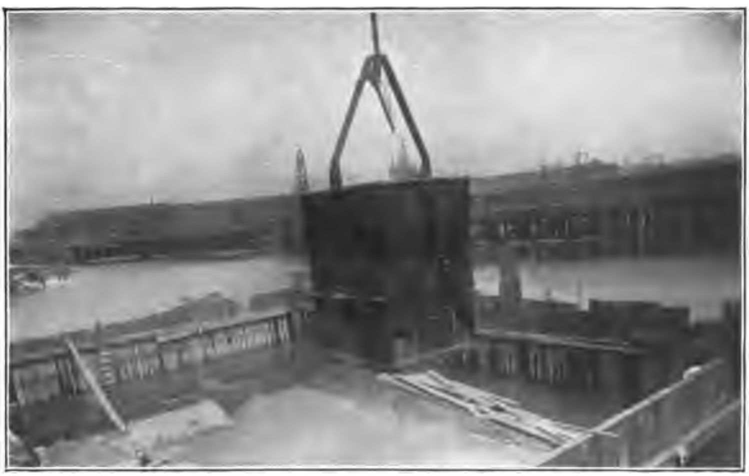

Fig. 8. Bucket for placing Concrete under water.

Fig. 9. Backing for Arch-Rings at Piers.

Fig. 10. Reinforcement and Buttresses to support Girders over Prison Point Street.

laitance as formed on the top of pier 8 and cut away to sound concrete, also the general appearance of the top of the concrete in piers which were laid under water.

Stone Laying. — The granite for facing the piers was furnished principally by the H. E. Fletcher Company, West Chelmsford, Mass., a very small portion, about 5½ per cent., being furnished for piers 3, 4, 9 and 10 by Sweatt & Gould, of Cambridge. The stone was delivered f. o. b. cars at the draw of Boston & Maine Railroad, Minot Street yard, unloaded directly on to lighters, from which it was laid in the foundations.

The concrete backing for the granite was brought up with each course as laid, but the spandrel backing (see Fig. 9), which was reinforced, was built as a unit before the balance of the backing was placed.

Piers 1, 11, 12 and 13 were all land piers and built by the Holbrook, Cabot & Rollins Corporation under a contract dated January 25, 1910. Piers 1, 12 and 13 were special, and 11 was similar to the river piers. Piers 12 and 13 were designed to carry the steel girders spanning Prison Point Street, and were located on the east and west sides of the street respectively. Buttresses, heavily reinforced, were built supporting the bridge seats, the reinforcing rods running well down into the foundations; the end walls of the piers were also well reinforced. (See Fig. 10.)

Superstructure.

Contracts. — A contract was made April 8, 1910, with the Holbrook, Cabot & Rollins Corporation, for building the rest pier at the ship lock, the falsework for new bridge to grade 121.00, and removing the old Boston & Maine Railroad freight bridge. Previously to this, arrangements had been made with the Charles River Basin Commission and the Boston & Maine Railroad, by which the Boston Elevated Railway Company acquired the old freight bridge for substantially the cost of its removal. The materials from this bridge were of the utmost value in the construction of falsework and forms; about 700 000 ft. b. m. and 1 500 piles were so used. Another contract was made with the same firm, August 24, 1910, for building the concrete superstructure; both of these contracts being made on a percentage basis.

Plant. — The plant for this work was supplied in part by the contractor and in part by the Boston Elevated Railway Company.

All derricks, lighters, pile drivers, buckets, diggers, engines,

boilers, concrete mixer, air compressor and all small tools for placing and handling concrete were furnished by the contractors.

The Boston Elevated Railway Company furnished a fully equipped wood-working mill for form work, stone pocket, one concrete-mixer, elevators, cars, track and electric locomotive for distributing concrete, pneumatic hammers for finishing concrete, electric motors for operating mill and mixers, and all

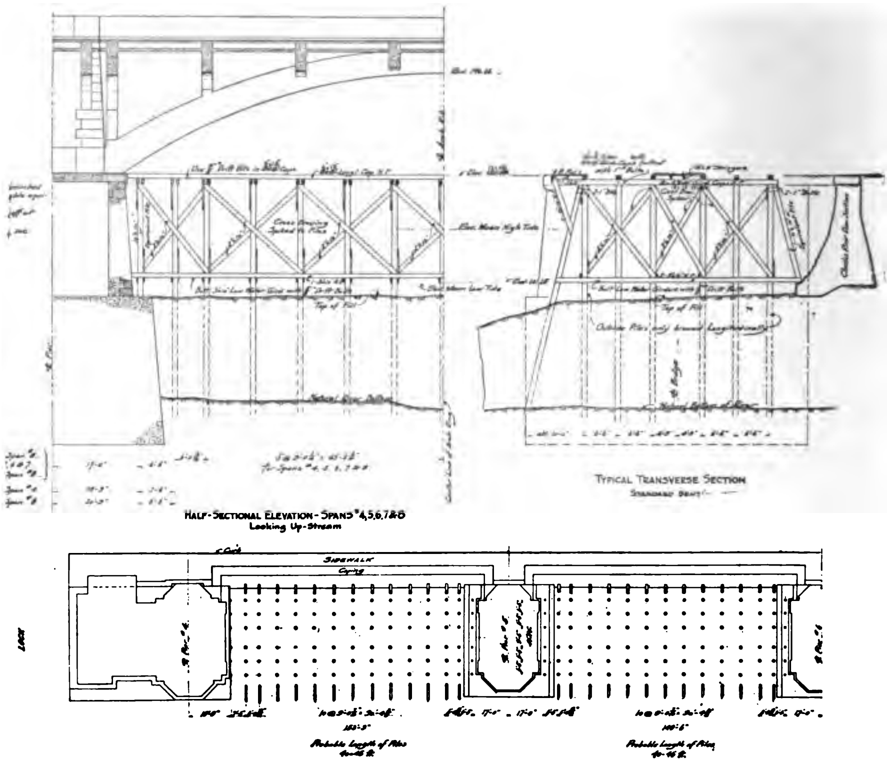

FIG. 13. FALSEWORK FOR PLATFQRM TO GRADE 121.

machinery for operating mixers, and electric current for light and power. The general layout of concrete-mixing plant and accessories is indicated by Fig. 11. Nearly all supplies were brought in on the spur tracks in the rear of stone pocket, the stone and dust being unloaded by a digger bucket directly into the stone pocket, and the cement from the track alongside into the room provided under the stone pocket.

The concrete was raised from the mixer by an elevator consisting of an Insley self-dumping bucket, discharged into a hopper capable of holding two yards, and from the hopper into

FIG. 11. MILL, STONE-POCKET, CEMENT SHED, DERRICK UNLOADING CRACKED STONE, ELEVATORS FOR CONCRETE AND INDUSTRIAL RAILWAY.

FIG. 12. LOCOMOTIVE AND CAR FOR DISTRIBUTING AND PLACING CONCRETE.

the Smith side-dump distributing cars. The cars were run to the site of the work over the double track line of 2 ft. gage, by means of a 3-ton Jeffrey electric locomotive, where they were discharged through chutes directly into place. (See Fig. 12.)

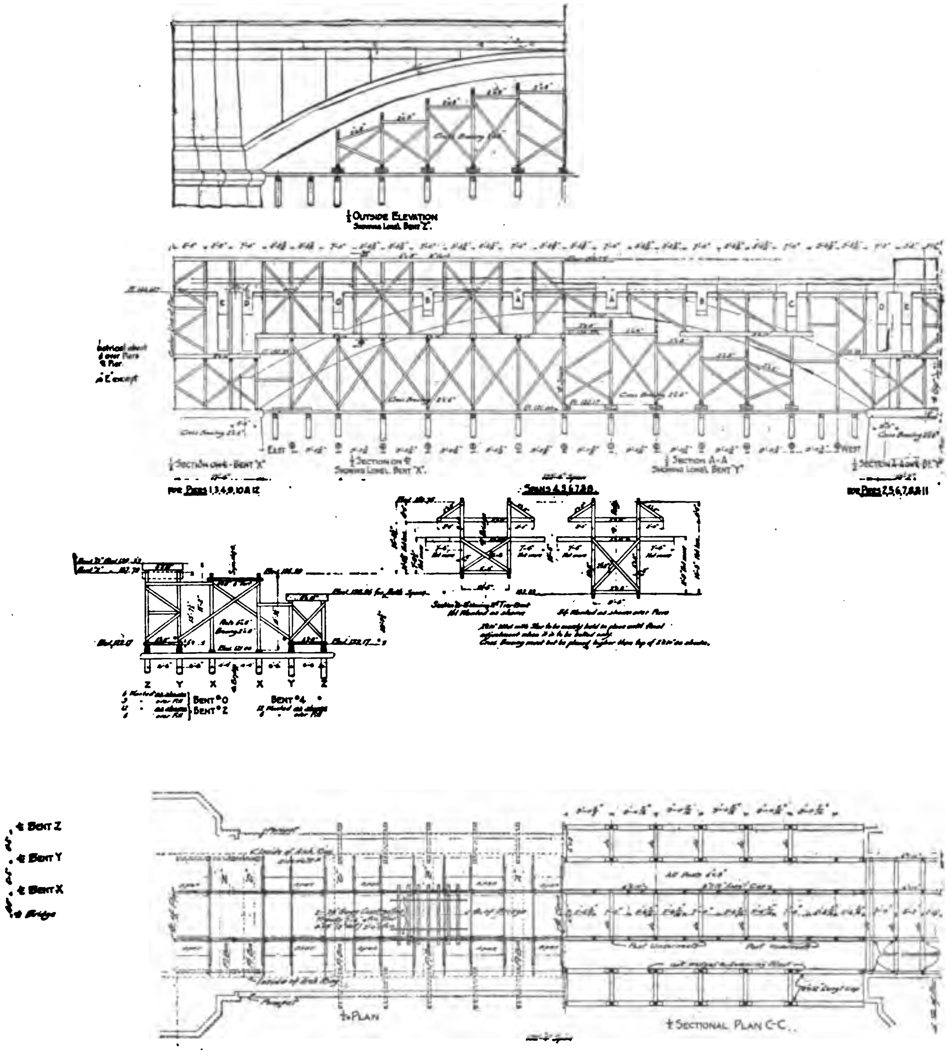

FIG. 14. FALSEWORK SUPPORTING FORMS ABOVE 121, AND TRACK.

Falsework. — In constructing the superstructure, the first step was to provide suitable supports for the falsework. A scheme was adopted providing for a pile structure of 12 to 16 bents, depending on length of spans, and so designed that the

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loads of the arch rings came directly down posts placed on wedges and bolsters directly over the piles. The two middle rows of piles parallel to the axis of the structure, supported bents designed to carry the floor system, track stringers and the industrial railway for carrying the concrete and supplies. (See Fig. 13 and 14.) The entire system of false work was arranged to be moved forward with the progress of the work, and was, in fact, used about three times in the length of the bridge.

Forms. — The final appearance of any concrete structure is largely due to the care and accuracy with which the forms are made. Particular attention was given to this part of the work, and the resulting work bears evidence that it was well carried out. The side forms for the arch ring were built in sections about 9 ft. long, made of 2-in. by 6-in. spruce, the boards set radially. The forms for the label mold on the arch ring, and belt course at the sidewalk level, were made of cypress, and were afterwards remade into forms for the balustrade; some of these forms were used six or seven times.

The forms for the spandrels and the floor system were of spruce, made in panels and used on an average of four times. Forms for the piers which were uniform were made in panels, but as piers 1, 3, 4, 12 and 13 were special, all the forms were built in place and were quite expensive. Fig. 15 will show in a

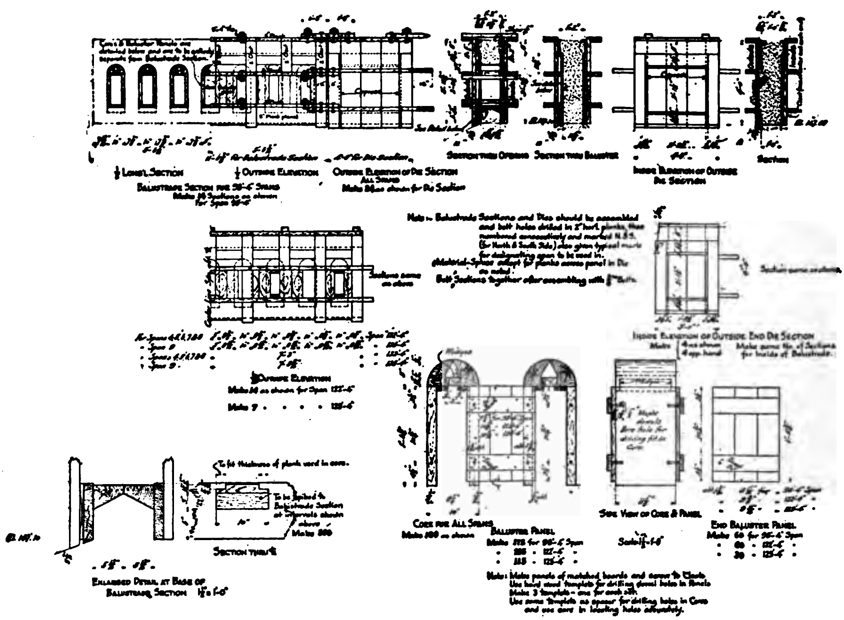
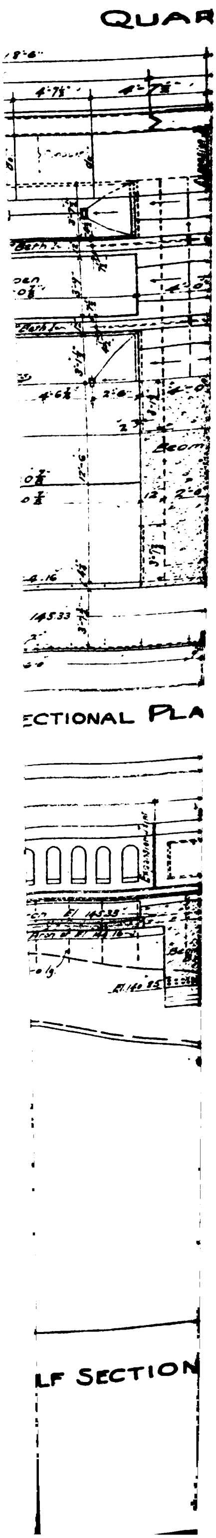
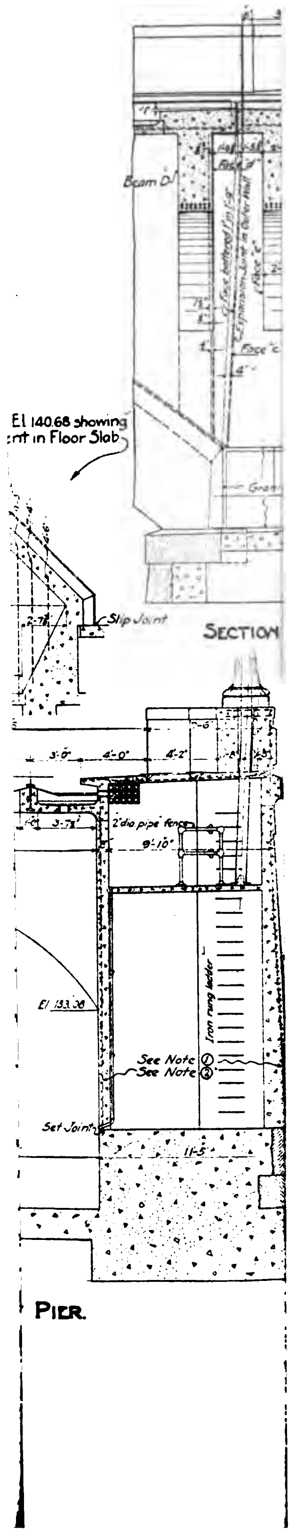


FIG. 15. FORMS FOR BALUSTRADE.


QUAR
ECTIONAL PLA
LF SECTION


El 140.68 showing
nt in Floor Slab
Beam D
Face "c"
Slip Joint
SECTION
3'-0"
4'-0"
4'-2"
2" dia pipe fence
9'-10"
Iron rung ladder
El 153.08
See Note 1
See Note 2
Set Joint
11'-5"
PIER.

typical manner how the special features for the difficult forms were worked out. The mill proved invaluable for turning out this work with speed and accuracy.

The centers for the jack arches or floor beams were built in three sections bolted together and set on wedges; this permitted adjustment to line and grade, also ease in removal; and the reinforcement was built in place before the side forms were put on. All the forms were given a coat of dead oil as they were completed.

Concreting. Reinforcing. — Coincident with the building of the forms the reinforcing was placed, and in the case of the

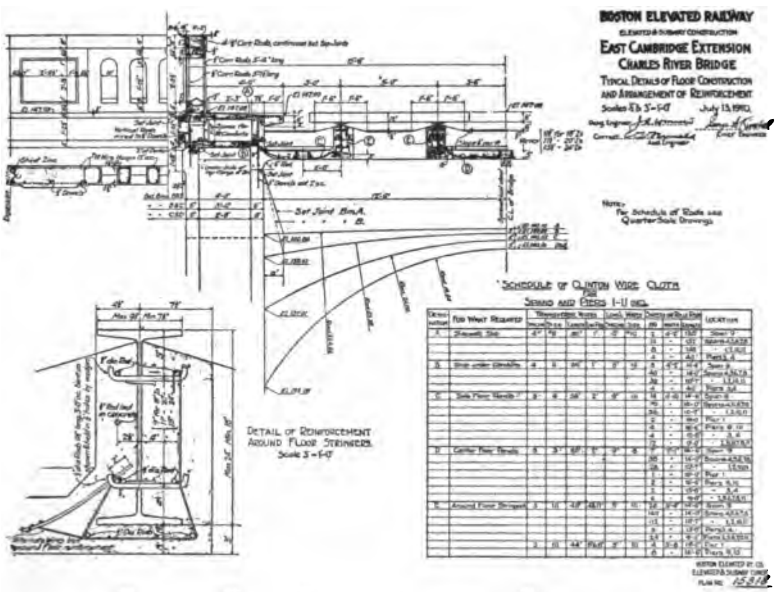


Fig. 20. Floor Reinforcement and Balustrade.

arched rings, hinges of cast steel and cast iron were set at the skew back, thus making them virtually two hinged arches. These hinges (see Fig. 16) weighed approximately 5 tons each; the skew back was of cast iron; the arch seats of cast steel, working on a 9-in. pin of drop forged steel. They were concreted in place up to a radial line through the center of the pin, and a zinc separator was placed on this when the balance of the ring was poured, to prevent a bond, and in case of movement allow the hinge to work.

The arch rings were reinforced with twelve $1\frac{1}{4}$ in. corrugated steel rods, six on the extrados and six on the intrados of the ring, spaced $8\frac{1}{2}$ in. on centers and 3 in. from the faces of ring. Fig.

18 and 19 show general plan of reinforcement of typical arch and pier, also location of expansion joints. Fig. 20 and 21 give detail of reinforcement for floor beams and floor system.

Mixing and Placing. — The concrete was all of a 1 : 2 : 4 mixture, made with Giant cement, and aggregate of crushed Chelmsford granite in varying sizes, and granite dust instead

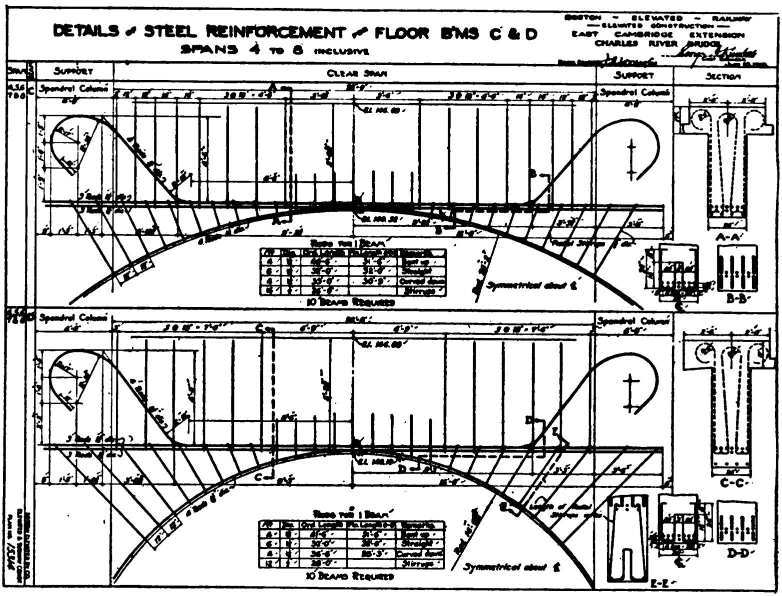


FIG. 21. REINFORCEMENT FOR FLOOR-BEAM OR JACK ARCH.

of sand. It was mixed and placed as described previously, nearly all being dumped into its final place by means of chutes with the minimum amount of labor. The cost of this work varied largely, that for the arch rings costing less than one half that for the floor beams and panels. Fig. 24 shows method of pouring the arch rings, and Fig. 22 that of pouring a portion of the floor.

The program pursued in construction was as follows: Forms for the arch rings and centers for the two central floor beams were erected, the reinforcement placed in the floor beams and the arch ring poured, the floor beams or jack arches were next poured (Fig. 17), working from the center of the arch towards the springing line, and then the floor panels (Fig. 23), and this was followed by the spandrel walls (Fig. 25).

Next in order the outside floor panels were completed and the cable ducts laid, then followed the sidewalk and balustrade,

FIG. 16. HINGE IN PLACE PREPARATORY TO CONCRETING.

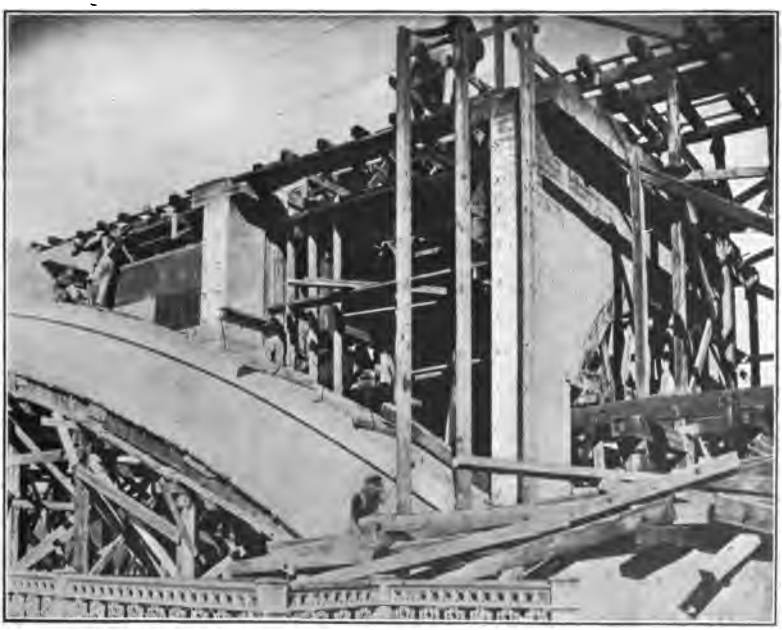


FIG. 17. FLOOR-BEAMS READY TO START FORMS FOR SPANDREL WALLS.

Fig. 22. Pouring Floor Panels.

Fig. 23. Floor System, showing Reinforcement for Floor Slabs, Track Girders in place and Scuppers set.

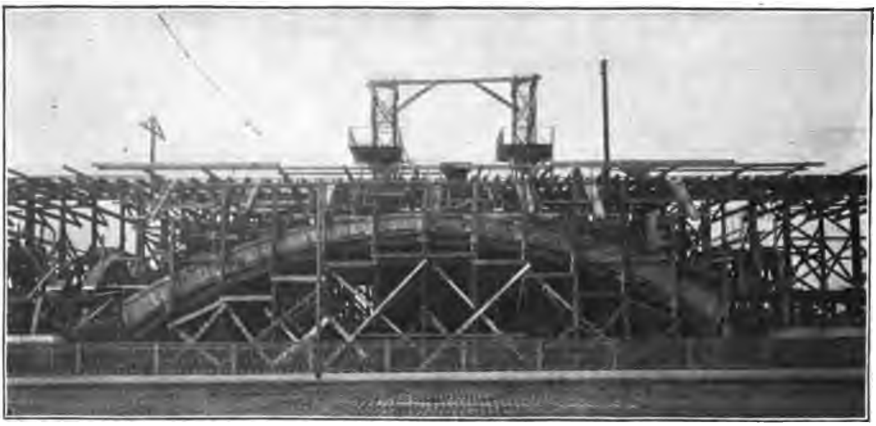


FIG. 24. FORMS AND CHUTES READY TO POUR ARCH-RING.

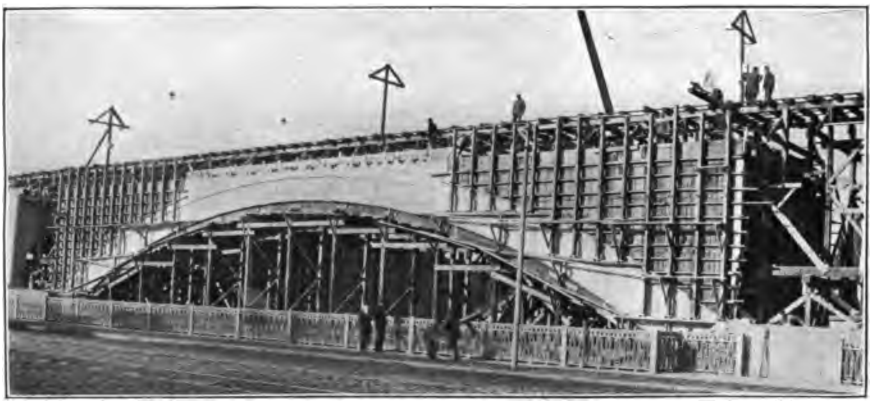


FIG. 25. SPANDREL FORMS IN PLACE.

FIG. 26. METHOD OF PASSING CONCRETE ACROSS LOCK.

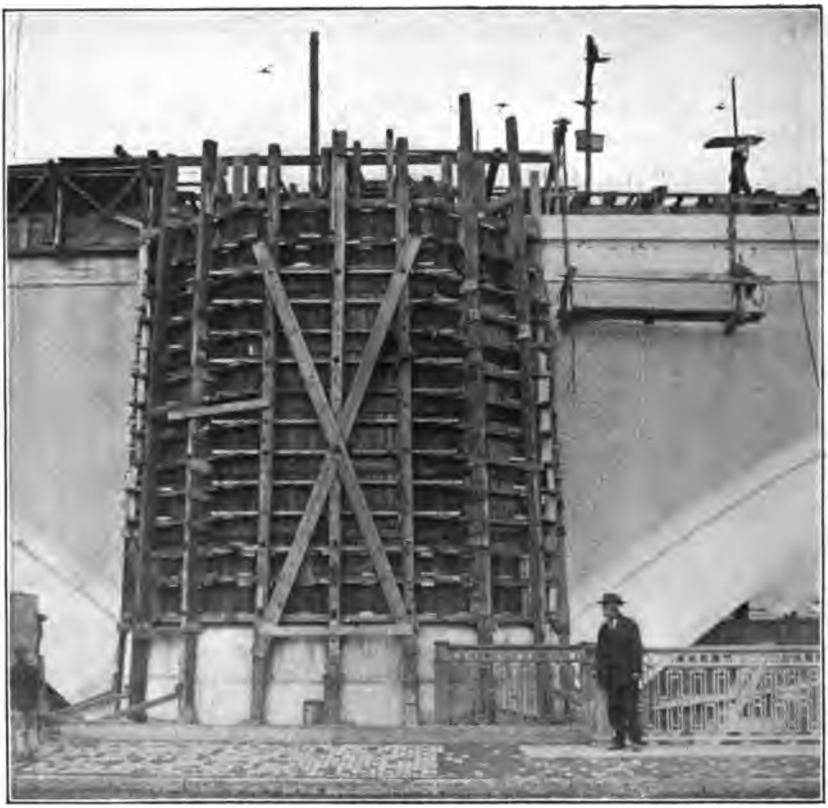


FIG. 27. OUTSIDE FORM, FOR PIER.

FIG. 28. LONGITUDINAL VIEW OF UNDER SIDE OF BRIDGE.

Fig. 29. Old Craigie Bridge from Cambridge side looking toward Boston.

Fig. 30. Various stages of progress in three months from turning first Arch-Ring.

Fig. 31. Reinforced Concrete Trolley-Poles.

FIG. 32. DRAW, OPEN, SHOWING PANTAGRAPH TROLLEY SUPPORT.

FIG. 33. AUTOMATIC BUMPER SET AT DANGER, ALSO PANTAGRAPH TO SUPPORT TROLLEY WIRE, AT DRAW.

and last the piers (Fig. 27) were poured. The general view (Fig. 30), taken November 14, 1910, or three months after the first arch ring was turned, shows the order of the work as above described.

The concrete for the two spans and three piers on east side of the lock was transferred across the lock in buckets by a lighter derrick, and the dump cars pushed by hand to the site of the work (Fig. 26).

The structure over Prison Point Street is of steel encased in concrete; the tracks are carried on four plate girders of 72 ft. 8 in. span and 6 ft. deep, and the balustrade by a lattice girder encased in concrete.

Fig. 28 shows clearly the type of construction of the main members of the concrete bridge.

The trolley poles were cast in a vertical position, the reinforcing being attached to the iron pole itself. These poles were made during the most severe winter weather, and to facilitate the setting of the concrete a shelter was constructed and heated by a steam coil from the boiler of the derrick engine; a coil was also placed inside the tube of the pole; by this means six poles a week were turned out. (Fig. 31.)

Drawbridge. — The drawbridge over the entrance to the main lock is of the Strauss patented trunnion type, with an underhung or pivoted counterweight, approximately 110 tons in weight. There are two leaves, one for each track, having a length of 70 ft. from center of trunnion to outer end. (See Fig. 32.) They are operated by two Westinghouse type K, 500 to 600 volt, d. c., 40 h. p. motors, and are so arranged that one motor can operate both leaves in case of emergency; there is also an auxiliary hand operating device.

There are emergency brakes which operate in the event of failure of the current, also several devices to control the main current operating the bridge, pending the completion of the preliminaries of setting track signals, automatic bumpers (see Fig. 33), locking or unlocking the bridge, and six indicators announcing the completion of each stage in operation.

The bridge was completely installed, including all electrical equipment, by the Pennsylvania Steel Company, of Steelton, Pa.

The trolley wire across the draw is supported by a pantagraph which folds up with the draw, and has the advantage of keeping the trolley taut at all times (see Fig. 32 and 33).

The entire work was under the direction of Mr. George A.

Kimball, chief engineer, with the author directly in charge; it was completed in December, 1911, and on June 1, 1912, the line was opened for traffic.

The following statistics relating to the size of the bridge and the quantities of material used are of interest.

Length	1 738 ft.
Width between balustrades	31 ft.
Number of piles used in foundations	5 790
Amount of concrete in foundations	24 633 cu. yd.
Amount of granite masonry in piers	3 846 cu. yd.
Amount of concrete in superstructure	9 000 cu. yd.
Amount of reinforcing rods in superstructure	395 tons.
Amount of cast steel in hinges in superstructure	200 tons.
Amount of I-beams in track stringers in superstructure	200 tons.

The successful completion of this bridge was due to the coöperation and the faithful and efficient work done by all, from the contractor to rodman; but especial credit should be given to Mr. C. W. Rogers, resident engineer on the work; Mr. John E. Cunningham, for his attention to details on form designs; Mr. G. C. Cappelle, in charge of lines and grades; and the office of J. R. Worcester & Co., the designing engineers.

DISCUSSION.

Mr. J. R. Worcester (*by subsequent letter*). — The unusual features of this bridge which render it somewhat unique are as follows:

1. The arrangement of all parts so as to permit of a clear passageway underneath the bridge longitudinally for possible future service.

2. The combination of reinforced concrete main members with structural steel members in certain places.

3. The attention given by the architects to the lines and proportions of the structure, to harmony with environments, details of design and perfection of finish.

4. The care devoted to the bridge by the author in executing the work with extreme precision as to form and detail.

The design was evolved from a long and careful study which included various materials of construction and different span lengths. The necessity for the eccentric location of the draw to come where the lock had already been placed in the dam prevented perfect symmetry, and the balance of this feature with the rest of the structure involved some difficulty. The archi-

tects wished to give the floor a slight camber, but it was considered by the operating department too dangerous to put the draw on a down grade for cars in one direction.

An ordinary steel elevated structure would have been the most direct and economical method of providing for the clear passageway below, but the inferiority of the appearance of such construction was sufficient reason for ruling it out. Had it not been for the depth of water and the somewhat yielding bottom, the difference in expense between the steel and reinforced concrete designs would not have been very great, but, with the condition encountered, very large piers were required for the concrete bridge, particularly at the draw, thus materially increasing the difference between the two types of construction.

The necessity for the clear sub-passage prevented the use of a thin, wide arch with open spandrels, which would have been a more natural design for masonry, and called for the two-rib type of construction with the heavy floor spanning from rib to rib. With the general form of ribs and floor adopted, it would have been possible to have left the spandrels open, as they serve no purpose of construction, but for architectural considerations they were filled in with two thin walls, leaving a space between. It was evident that if the spandrels were made monolithic with the arch, the bending due to temperature stresses would have been localized at the crown, and it was deemed better to allow joints between each bay of spandrel wall and the surrounding members of the main skeleton.

As stated by the author, the original design for the floor was to have a solid reinforced concrete slab carrying ballast. This was abandoned mainly for the reason that it would have been troublesome to free it from snow in winter, though, incidentally, the saving in weight by using an open floor was a great advantage in reducing load on the foundations. Having decided upon an open floor, the possibility of using reinforced concrete stringers to carry the ties was considered, but was not adopted. It was thought that it would be difficult, if not impracticable, to get the tops of these members sufficiently true to line and grade to secure uniformity of cross ties, and the easy renewal and attachment of ties would have presented grave difficulties. On the other hand, by embedding steel I-beam stringers, a standard elevated railway floor system is possible. The fact that the openings through the floor do not cover all the space between floor beams is due to the necessity of getting a T section with wide top flange for the cross beams. The arched bottom of the

cross beams is largely a concession to the architects, though it adds to the transverse stiffness of the structure.

Too much credit cannot be given to the architects for their painstaking study of the problem. Not only were innumerable drawings made in elevation and perspective, but even models were constructed and worked over. The thought bestowed on what to engineers seem insignificant points afforded a lesson to our branch of the profession. The work of the architects also included experiments in concretes with aggregates of many kinds, and with different kinds of surface treatment. The success in these particulars can only be appreciated by an examination of the structure itself. It certainly has provided a striking object lesson as to what can be done with this material.

The writer also wishes to say a word with reference to the good judgment of the Elevated Railway Company in retaining the direct control of the work throughout, instead of attempting to cover in advance, by means of specifications, all possible contingencies that might arise, and then being obliged to accept at best a strict fulfillment of the terms of the specifications. The work contained many novel features, and problems inevitably arose as the work progressed which could not have been foreseen, but which could be solved to the satisfaction of all with the elastic arrangement adopted. Of course, under such conditions, constant, untiring, intelligent supervision was essential, and this was provided most efficiently by the author of this paper.

In conclusion, it may be well to supplement the author's table of statistics by some of the assumptions upon which the design of the structure was based.

The live load on each track was assumed to be a continuous line of cars 40 ft. long over all, weighing 50 tons each. This load was considered as uniformly distributed in the computation of arches and piers. In the floor members, the weight of a car was considered as divided equally between 4 axles, $5\frac{1}{2}$ ft., 20 ft., $5\frac{1}{2}$ ft. being the successive spacings under a car, thus making the distance from the end axle of one car to the end axle of the next, 9 ft. No impact was added to this load in considering the arches and piers, but in floor members impact according to the following formula was added: $I=\frac{300}{380+l}\times L$. In this formula, I=impact, l=loaded length of track, and L= stress from live load.

The tensile stress in steel was limited to 16 000 lb. per sq. in.

The compressive stress in concrete under flexure was taken as 650 lb. per sq. in. except when temperature stresses were included, when it was allowed to reach 850 lb. per sq. in.

Bearing on concrete, 650 lb. per sq. in.

Bearing on granite, 810 lb. per sq. in.

Shear in floor beams was limited to 120 lb. per sq. in. on the effective cross-section.

Bonding stress on rods was taken at 80 lb. per sq. in.

An allowance was made for a variation in temperature of 30 degrees from the normal.

The original intention was to have no hinges in the arches, but it was found that the temperature stresses at the spring would require abnormally large sections at these points, and, moreover, it was found that as filling of the adjacent dam progressed the weight of earth was causing slight settlements of the ends of the bridge piers next the dam. It was thought that the insertion of hinges at the spring would not only assist in the provision for temperature stresses, but would prevent possible unknown stresses due to unequal settlements.

The author has stated that the piles were assumed to carry eleven tons each, and this was the original intention for direct vertical loading. Considering the extreme load which may come from partial loads, this figure was in some cases exceeded by from two to five tons.

The steelwork of the draw span was designed according to the Boston Elevated Railway standard specification for steel structures.

[NOTE. — Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by December 15, 1912, for publication in a subsequent number of the JOURNAL.]

THE ULTIMATE DIMENSIONS OF THE LARGEST SEAGOING VESSELS.

By C. E. Grunsky, Member of the Technical Society of the Pacific Coast.

[Read before the Society, September 13, 1912.]

At the Twelfth International Navigation Congress, held at Philadelphia in May of this year, the speaker was "General Reporter" on the question: "Dimensions to be given to Maritime Canals. (Technical point of view. Probable dimensions of the seagoing vessels of the future.)" Professional engagements rendered it impossible for him to be present at the discussion of the recommendations which he presented, and he has not yet received any detailed account thereof. At this time, therefore, he can only state that the Congress was not ready to admit the desirability of setting any limit to the draft of seagoing vessels, that it did not adopt the reporter's recommendations and that the idea prevailed that the commercial requirements and harbor facilities at New York would continue to affect and would control the dimensions of the largest seagoing vessels.

The recommendations made by the reporter were as follows:

I. It is desirable that a limit be set to the draft of seagoing vessels.

II. Government aid should not be extended to the building or operation of seagoing vessels whose draft exceeds 9.5 meters (32.2 ft.).

III. There should be an international agreement fixing the maximum dimensions of seagoing vessels built or operated under government subvention, and there are tentatively suggested the following:

Length over all,	900 ft. (275 meters).
Breadth,	105 ft. (32 meters).
Draft,	32.2 ft. (9.5 meters).

IV. Any maritime canal which has locks with a usable length of 1 000 ft. (305 meters), a width of 110 ft. (33.6 meters) and a depth of water on the sill of 35 ft. (10.7 meters), will fulfill every reasonable requirement of commerce.

V. In a maritime canal a wet section five times as large as the immersed portion of the largest ship which is to use the canal is desirable, as also a depth of one meter under the keel; but these values are functions of the speed at which the canal is to be navigated and, therefore, to some extent also of the volume of commerce, and are to be determined by local conditions.

The dimensions noted in these recommendations must be understood to be only tentative. They were inserted as a basis for discussion and are set low rather than high for obvious reasons.

With slight modification of the text the paper presented by the speaker to the Congress is made the basis of his talk this evening.

There were six papers submitted to the Congress on the question above-named as follows:

No. 63, by G. de Thierry, Baurat, Professor an der Königl. Technischen Hochschule Charlottenburg, Mitglied der Internationalen Technischen Commission des Suez Kanals, Berlin-Halensee, Germany.

No. 64, by H. Vander Vin, ingénieur en chef directeur des ponts et chaussées, Antwerp, Belgium.

No. 65, by Dr. Sc. E. L. Corthell, civil engineer, New York, United States.

No. 67, by J. Foster King, chief surveyor to the British Corporation for the Registry of Shipping, Glasgow, Great Britain.

No. 68, by C. Leemans, civil engineer, Amsterdam, Holland.

No. 69, by E. I. Zamjatin, naval engineer, St. Petersburg, Russia.

The question, "Dimensions to be Given to Maritime Canals. (Technical point of view. Probable dimensions of the seagoing vessels of the future)," relates specifically to the minimum dimensions of the canals and to the dimensions of the large seagoing vessels. The inter-relation of the size of the largest seagoing vessels and of the required dimensions of the canals is recognized in the question.

If it be admitted that the dimensions of the seagoing vessels are to be determined solely by the needs of trade and commerce, by economy of operation and by the demands of passengers for speed, comfort and luxuries, without regard to harbor facilities and without regard to the possible usefulness of the vessels to their governments in case of war, then it becomes comparatively easy to predict future growth. As Dr. Corthell contends, the

law would really be inexorable, and no one could foresee a limit to the size of the largest vessel.

But, and perhaps fortunately, there are other considerations to be taken into account, notably the general usefulness of large vessels, which, according to their size and particularly their draft, may be materially restricted by the dimensions of maritime canals and the depth of the approaches to the principal harbors of the world. To this point particular attention was drawn and the Twelfth International Navigation Congress was asked to consider whether or not it is desirable to point out other means of restricting the rate of increase in the size of vessels than only by the demands of the shipowners and the ability of the shipbuilders to comply with these demands.

It appears from all of the papers which were submitted that there is no check yet apparent to the rate at which the dimensions of the largest seagoing vessels are increasing. The vessel of over 50 000 tons is being built, and those who should know expect the vessel of 70 000 tons or more to put in her appearance soon.

Would this be possible without government aid? Some of the transatlantic steamship companies are so heavily subsidized that their ships are practically in government ownership. On the Pacific, too, the economic success of transportation in large vessels is made possible by subsidies in one form or another. Our own country, which does not subsidize, is out of the running. It has no merchant marine to speak of. In other words, the operation of large steamers without subsidy is not profitable; at any rate, not in competition with subsidized vessels.

And yet, if commerce between nations had been developed without government aid, and if the commerce on the high seas had been and were carried on only by vessels of moderate size, there would have been a suitable adjustment to such conditions and there would be little if any less volume of business between nations than is found to-day.

Perhaps, upon careful analysis, it may, even under the prevailing conditions, be found preferable to operate ten steamers of 10 000 tons each, rather than only two of 50 000 tons. From the standpoint of the government of any maritime country it would certainly be more desirable to have at its disposal when needed ten ships of 10 000 tons than two of 50 000 tons. The papers which were submitted to the Congress will now be briefly reviewed.

Mr. G. de Thierry, after making the statement that the largest ocean vessels are always those on the routes between Europe and North American ports, refers to the fact that there is also an ever-increasing size of vessels on other routes. He calls attention to the falling off in the number of vessels of smaller tonnage. He illustrates with a reference to the aggregate tonnage of British steamers in classes according to size, showing a decrease in aggregate tonnage of the small steamers, less than 1 000 tons, after 1884; and showing also a decrease of the aggregate tonnage of steamers from 1 000 to 2 000 tons after 1895.

How the ever-increasing size of vessels has compelled the enlargement from time to time of maritime canals and harbor approaches is referred to and examples are cited. Among these are such instances as: — the improved Weser, where the present requirements were not foreseen when the improvements were planned by Franzius in 1879 to 1881; the Kaiser Wilhelm Canal, built in 1887 to 1895, and now being enlarged at a great cost; the Suez Canal, which has been made wider and deeper and now has sufficient depth for vessels with 28 ft. (8.53 meters) draft.

The report of Mr. de Thierry then contains valuable facts relating to the Suez Canal, and he shows that with every increase in depth larger vessels have made use of the canal. But notwithstanding this fact, he says, it is not justifiable for economic reasons to take the ultimate dimensions of ocean vessels as a guide in planning a canal. However, due consideration should be given at the outset to the possibility of future canal enlargement.

In part three of his report Mr. de Thierry treats the construction of ship canals from the technical standpoint, dealing exhaustively not alone with the dimensions in their relation to the requirement of the shipping which is to use the canal, but also with the more involved engineering problems. This part of the report is full of valuable information for the engineer with extended references to the Suez Canal and to the Kaiser Wilhelm Canal.

In the matter of the relation of the sectional area of the waterway to the area of the immersed portion of the largest vessel which is to use the canal, Mr. de Thierry reaches the conclusion that the former should be five times the latter.

Among the conclusions which Mr. de Thierry formulates there may be particularly noted his first, according to which only the dimensions of vessels ruling at the time of the canal construction should be taken into account; his fifth, that the depth

of water under the vessel of greatest draft should be 1 meter (3.28 ft.); and his sixth, already noted, that the area of the canal section should be at least five times that of the largest vessel.

Of these, the first seems predicated upon purely financial reasons and, if literally construed, would in most cases be too severe a restriction. It is in line, however, with his view that at first recourse should be had to sidings rather than to a width throughout that would be required for passing vessels at any point of the canal. The conclusions with reference to depth of water under the keel and the area of the canal section come with full force from an engineer of experience. Anything less than the values here suggested would be more or less of a restriction upon the usefulness of a canal.

Mr. H. Vander Vin, referring to the dimensions of larger vessels, believes that, especially draft and length considered from the point of view of stability, the maximum point on the curve of increase may have been reached.

The author emphasizes the interrelation between draft of vessels and the depth of harbors and the inconvenience that would result if vessels have such draft that they can enter the ports only during the short period of high tide. Based mainly on the data collected by Dr. Corthell and published by him in his report to the Tenth Congress of this Association at Milan on the "Rapid Increase in the Dimensions of Steamers and Sailing Vessels, etc.," Mr. Vander Vin presents instructive tables showing existing or contemplated entrance depth of harbors at mean low water and at mean high water, from which it appears that among those with less than 9 meters (29.5 ft.) at mean low water there would be such important ports as:

In Australia:	Melbourne	with	8.50	meters
	Williamstown	"	8.20	"
	River Yarra	"	7.90	"
	Port Adelaide	"	7.00	"
	Newcastle	"	6.10	"
In Belgium:	Ghent Canal	"	8.70	"
	Antwerp	"	7.50	"
In England:	Manchester	"	8.50	"
	Hull	"	7.30	"
	Barry Docks	"	6.60	"
	Blyth	"	6.10	"
In France:	St. Nazaire	"	7.00	"
	La Pallice	"	6.90	"
	Boulogne	"	6.80	"
	Dieppe	"	6.40	"

In France:	Bordeaux	with	6.10	meters
	Havre	,,	6.10	,,
	Bayonne	,,	6.00	,,
	Nantes	,,	6.10	,,
In Germany:	Lübeck	,,	8.50	,,
	Harburg	,,	8.20	,,
	Bremer Haven	,,	8.00	,,
	Hamburg	,,	8.00	,,
	Koenigsberg	,,	6.50	,,
	Stettin	,,	6.50	,,
	Warnemünde	,,	6.00	,,
In Greece:	Corinth	,,	8.00	,,
In Holland:	Rotterdam	,,	8.00	,,
In Italy:	Savona	,,	8.80	,,
	Venice	,,	8.20	,,
	Cagliari	,,	8.00	,,
	Spezia	,,	7.80	,,
	Civita Vecchia	,,	7.20	,,
In India:	Bombay	,,	8.70	,,
	Calcutta	,,	8.20	,,
In Ireland:	Dublin	,,	6.10	,,
In Mexico:	Tampico	,,	8.20	,,
In Russia:	Cronstadt	,,	8.50	,,
	St. Petersburg	,,	8.50	,,
	Libau	,,	7.90	,,
	Riga	,,	6.70	,,
In Roumania:	Constanza	,,	8.50	,,
	Sulina	,,	7.30	,,
In Sweden:	Stockholm	,,	7.70	,,
	Malmö	,,	6.70	,,
In Scotland:	Greenock	,,	7.00	,,
	Dundee	,,	6.70	,,
	Glasgow	,,	6.70	,,
	Aberdeen	,,	6.10	,,
In the United States:	Norfolk, Va.	,,	8.50	,,
	San Diego, Cal.	,,	8.50	,,
	Charleston, S. C.	,,	7.90	,,
	Astoria, Wash.	,,	7.60	,,
	Port Arthur, Tex.	,,	7.60	,,
	Portland, Ore.	,,	7.60	,,
	Providence, R. I.	,,	7.60	,,
	Mobile, Ala.	,,	7.00	,,
	Savannah, Ga.	,,	6.60	,,
	Wilmington, Del.	,,	6.40	,,
	Brunswick, Ga.	,,	6.20	,,
	New Haven, Conn.	,,	6.10	,,
	San Pedro, Cal.	,,	6.10	,,

Mr. Vander Vin enumerates among the harbors which have less than 9 meters (29.5 ft.) of water at mean high water such important harbors as:

In Africa:	Durban (Port Natal)	with 8.50 meters
	Dar el Salaam	„ 8.50 „
	Tunis	„ 7.10 „
In Australia:	River Yarra (Vic.)	„ 8.70 „
	Newcastle (N. S. W.)	„ 7.30 „
In the Argentine Rep.:	Buenos Aires	„ 8.20 „
In Belgium:	Ghent Canal	„ 8.70 „
In Brazil:	Pernambuco	„ 7.00 „
In China:	Shanghai	„ 6.10 „
In England:	Manchester	„ 8.50 „
In France:	Bayonne	„ 8.90 „
	Rochefort	„ 8.90 „
	Nantes	„ 8.50 „
	Bordeaux	„ 7.30 „
	Rouen	„ 7.20 „
In Germany:	Lübeck	„ 8.50 „
	Pillau	„ 8.00 „
	Swinemünde	„ 8.00 „
	Geestemünde	„ 7.70 „
	Stettin	„ 7.70 „
	Dantzig	„ 7.00 „
	Kiel	„ 7.00 „
	Koenigsberg	„ 6.50 „
In Greece:	Corinth Canal	„ 8.00 „
In Italy:	Venice	„ 8.20 „
	Spezia	„ 8.10 „
	Civita Vecchia	„ 7.70 „
In India:	Calcutta	„ 8.20 „
In Russia:	Cronstadt	„ 8.50 „
	St. Petersburg	„ 8.50 „
	Libau	„ 7.90 „
In the United States:	Savannah, Ga.	„ 8.70 „
	Bangor, Me.	„ 8.20 „
	Brunswick, Ga.	„ 8.20 „
	Wilmington, Del.	„ 8.20 „
	Port Arthur, Tex.	„ 8.10 „
	New Haven, Conn.	„ 7.90 „
	San Pedro, Cal.	„ 7.60 „
	Mobile, Ala.	„ 7.50 „
	Washington, D. C.	„ 7.00 „

It has not been possible for the speaker to verify these figures of entrance depth, but they are quoted from the tables in order to show that among the harbors that have an entrance depth of less than 9 meters, there are many of importance.

Unless these harbors can be improved to greater depth at reasonable cost, they will exert a limiting effect upon the draft of the vessels which are to enter them. It follows from this that the growth of commerce on new routes of travel, the increasing

commerce of Europe and America with South America and with the Orient, with China, with Japan and Australia, which, with the completion of the Panama Canal, may be expected to grow more rapidly than that between New York and Europe, will have a retarding effect upon the rate at which the size of the large ocean vessels as a class is increasing. At the same time it may reasonably be assumed that it will be without effect upon the rate of increase in the size of the largest vessels which are found only upon the route between Europe and New York.

Mr. Vander Vin points out how of necessity a canal of small dimensions would exclude the large vessels, and gives a summary of the vessels which entered the port of Antwerp in 1910. Of the total number, 6 973, he says that only 0.7 per cent. had a draft of 7.50 meters.

He believes that in the maritime canal which extends inland from the sea a depth of 0.75 meters (2.45 ft.) under the keel would be adequate and that the minimum navigable depth in such a canal should be 8.25 to 8.50 meters.

The ratio of the sectional area of the submerged part of the vessel in a canal and the water in which it floats he places at 4 to 5, using in his estimate of required minimum canal width the factor 4.5. For 1 on 3 bank slopes the bottom width should be 129 ft. (39.50 meters).

He considers that prudence demands that any canal constructed to meet only the demands of the present and of the near future should be so constructed that it will permit of future enlargement.

Perhaps no one is better qualified to discuss the probable future dimensions of ocean vessels than Dr. E. L. Corthell. He has given this matter close attention for many years and in 1898 wrote an exhaustive report on "Maritime Commerce" for the fiftieth anniversary of the Association for the Advancement of Science in the United States of America, in which he dealt with this subject, and he now points out in Paper No. 65 that his predictions as then made are behind the actual dimensions of to-day, and that in the case of load draft the actual average of the twenty largest steamships of 1911 exceeds his predictions for 1948 by 2 ft. (0.61 meters).

Dr. Corthell emphasizes the need of giving consideration to the transatlantic "liners" and to the warships of the world. The former must receive consideration in planning the dimensions of maritime canals because every one of the great maritime

powers of the world may in the case of war make requisition for any ship of its flag for war purposes.

There is not, therefore, he says, any great maritime canal that may not be called upon at any time to let these ships pass, that is, the *Olympic*, *Aquitania*, *Europa* and other of the great North Atlantic liners.

After the dimensions of the Panama Canal locks were fixed by the Isthmian Canal Commission, in 1905, at a usable length of 1 000 ft. and a clear width of 100 ft. (the minority of the Board of Consulting Engineers had recommended a length of 900 ft. and a width of 95 ft.) it was found by the General Naval Board of the United States that these dimensions might at an early date prove inadequate and they were increased. The locks as now being built will be 110 ft. wide and will have a usable length of 1 000 ft.

Such facts as these are, says Dr. Corthell, "simply illustrative of the statement that a maritime canal must be designed to take the largest merchant and naval ships of the world, and that their requirements are not sufficiently appreciated."

That these views are to prevail is borne out by the fact, according to Dr. Corthell, that the locks of the Kaiser Wilhelm Canal are to be 1 083 ft. (330 meters) long, 148 ft. (45 meters) wide and 45 ft. (13.77 meters) deep, and also by the fact that the Port of London Authority has fixed the dimensions of entrance locks as follows:

For South Albert Dock, 850 ft. (259 meters) long, 110 ft. (33.5 meters) wide and 48 ft. (14.6 meters) deep on the sills.

For the North Albert Dock, 1 000 ft. (304.8 meters) long, 120 ft. (36.5 meters) wide and 52 ft. (15.8 meters) deep on the sills.

For Tilbury Docks, 1 050 ft. (302 meters) long, 130 ft. (39.6 meters) wide and 55 ft. (16.8 meters) deep on the sills with means for extending the lock to take vessels 1 250 ft. (381 meters) long by the use of a caisson at the inner end.

Dr. Corthell contends "that the size of merchant ships is determined by the inexorable laws of commerce, trade, economy of transportation and the demands of passengers for room and comfort." He quotes in this connection Sir William H. White, formerly chief constructor of the British Navy and later designer of the Cunard ships *Mauretania* and *Lusitania*, also Prof. J. H. Biles, one of the greatest experts in naval architecture, and also Lord Pierie, to substantiate his contention that the building of large ships is economical and that the size of merchant ships is determined by the inexorable laws of commerce.

Dr. Corthell points out, too, that it is incorrect to assume that a maritime canal built for the largest commercial ships will be large enough for the war vessels, and he refers again to errors in conclusions of the consulting engineers for the Panama Canal (1905), who suggested dimensions of locks that would have been too small for warships already building.

The majority of the Board of Consulting Engineers, in 1905, though they favored a sea-level canal and merely considered the lock type as an alternative, suggested locks 1 000 ft. long by 100 ft. wide.

Dr. Corthell draws the conclusion from the relative dimensions of the Panama and the Suez canals that the latter must be further enlarged to give commerce what it requires, so that competition will redound to the benefit of all the world. He notes the reluctant concessions which have been made by the authorities of the Suez Canal to the steamships in the matter of draft: 7.50 meters (24.6 ft.) in 1869; 7.80 meters (25.5 ft.) in 1890; 8.00 meters (26.2 ft.) in 1902; 8.23 meters (27.0 ft.) in 1906; 8.53 meters (28 ft.) in 1908. This is the authorized draft in 1911, the canal having been deepened to 9.50 meters (31.2 ft.).

Speaking of the fact that increase in the draft of steamers 500 ft. (152.4 meters) long and upwards falls short of the normal increase, Dr. Corthell says that this is evidently due to the shallow depth of the Suez Canal and to the lack of depth in the approaches to the port of Buenos Aires and other harbors of restricted depth. He assumes that maritime canals of the larger class should be large enough to allow the passage of the larger class of commercial steamships in two directions simultaneously. There should, he says, be the same space at least between these ships and between them and the foot of the slopes as the width of the ships. From this the conclusion is reached that with bank slopes of 1 on 2 the wet section should be about 21 000 sq. ft. (1 951 square meters) and the bottom width about 375 ft. (114 meters). In rock or between retaining walls the bottom should be about 455 ft. (138.6 meters). The desirable clear height in the case of fixed bridges is placed by Dr. Corthell at 250 ft. (76.2 meters).

The locks should be large enough for vessels 1 100 ft. (335 meters) long; 110 ft. (33.5 meters) wide, with 40 ft. (12.2 meters) draft. Their dimensions should be as follows: Usable length, 1 150 ft. (350.5 meters); width, 130 ft. (39.6 meters) and depth of water 45 ft. (13.7 meters).

To canals of lesser importance the same general principles

may be applied. "The canal should be planned to take the largest possible ship that may wish to pass through within half a century, should the canal be a lock canal. A sea-level canal can be enlarged by dredging, or by under-water excavation if the material is rock."

The largest vessel is the least likely to suffer from the destructive powers of the sea, says Mr. Foster King, the author of Paper No. 67, and this fact coupled with economy of operation leads the shipowners on to the construction of the largest vessels justified by their interpretation of trade conditions. But the tendency to exceed certain limits of size is opposed by the dimensions of existing dry docks and by the depth of water at the entrance to ports.

Mr. King proceeds on the assumption that maritime canals include not only such as the Manchester Ship Canal, the Suez Canal, the Kiel Canal and the Panama Canal, but also entrances to ports such as the river Clyde, the Elbe, Ambrose Channel at New York, and others which have an influence upon the dimensions of ships and whose own dimensions are in turn influenced by the size of the largest vessels using them.

By the aid of diagrams he points out that the increase in length of the largest ships in the world from 1837 to 1907 has been about 66 ft. (20.1 meters) in ten years, and that after 1907 a number of vessels indicate a higher rate of increase, bringing the rate of increase up to 150 ft. (45.8 meters) in ten years. The largest vessels have been built for service between New York and Europe.

Vessels on other routes alone being considered, makes the increase in length of the largest vessels about 50 ft. (15.3 meters) in ten years.

Mr. King finds that apart from the "abnormal" steamers of *Lusitania*, *Mauretania*, *Olympic*, *Titanic*, *Imperator* and *Aquitania* type, the increase of breadth of beam has been at the rate of 8 ft. (2.44 meters) in ten years, and that this rate applies as far back as 1864. The abnormal vessels, however, indicate a rate in recent years of 21 ft. (6.14 meters) in ten years.

The draft in sixty years for passenger steamers other than those classed as "abnormal" has, he says, increased 50 per cent. (practically one third of the draft of to-day). The same increase in draft is noted for cargo steamers. The half dozen large

vessels of abnormal dimensions seem to have a mean draft of about 36½ ft. (11.1 meters).

Mr. King believes that the very large vessels plying between New York and Europe should be regarded as being in a class by themselves.

Referring to the largest passenger vessels on other routes, he says that it is apparent that some influence is holding back the rate at which their dimensions might otherwise be expected to increase. He intimates that the depth of navigable water in the important harbors of the world and the dimensions of the Suez Canal have been potent restraining factors, but believes that the depth of water in the Panama Canal — adequate for vessels with a draft of 40 ft. (12.2 meters) — and satisfactory traffic conditions on the Suez Canal will stimulate the rate at which the depth of the latter will be increased and that these canal facilities will react upon dimensions of ships and, therefore, also upon the harbors of the world.

Mr. King anticipates drafts of 27 to 40 ft. in 1970 for the bulk of ocean shipping of all types.

So long as there is uninterrupted development of the commerce between nations, and progress in the art of shipbuilding and increase of population, barring any unforeseen revolutions in the means of transportation, there will be no material change in the rate of increase in the size of ocean vessels. This is substantially the conclusion of Mr. King, and he believes, therefore, that those countries which desire to maintain their relative positions in the world must improve their harbors and canals to keep pace with this indicated growth of the vessels which are to use the ports or canals.

Mr. C. Leemans, the author of Paper No. 68, devotes considerable attention to the character and size of vessels on the various ocean routes of commerce, and predicts for each a more or less specific and for each a considerable increase in the size of the largest vessels. He dwells upon the fact that the enlargement and particularly the deepening of maritime canals has at once been followed by their being used by larger vessels, and he recommends two sets of dimensions for the maritime canals and canal locks, of which the first is for steamers serving the lines to New York, to Boston and Canadian ports, and the second for steamers of other ocean routes.

The dimensions of canals for steamers of the first class he would fix as follows:

Bottom width on straight section	120 meters.	
Bottom width on curves	140 ,,	
Depth	15 ,,	
Slope of banks, 1 on 3 to 1 on 3.5.		
Useful length of locks	470 ,,	
Useful width of locks	55 ,,	
Useful depth of locks	15 ,,	at high water.

The dimensions of other maritime canals he would fix as follows:

Bottom width on straight section	80 meters.	
Bottom width on curves	90 ,,	
Depth	11 ,,	
Slope of banks, 1 on 3 to 1 on 3.5.		
Useful length of locks	250 ,,	
Useful width of locks	35 ,,	
Useful depth of locks for a transit canal	12 ,,	at low water.
Useful depth of locks for a canal giving access to a harbor	12 ,,	at high water.

The larger canal dimensions would be required to fulfill " the greatest demands of the future, navigable by a vessel 160 ft. in width, having a draft of 14 meters." It is the author's contention that the conditions in the harbor of New York really determine the dimensions of the maritime canals of the first class, because that port is frequented by all the largest vessels. He believes it desirable that the principal harbors of Europe should offer the same depth as the harbor of New York. The entrance into the New York harbor, the Ambrose Channel, is being maintained at a depth of 12.19 meters (40 ft.) at low water, or 13.8 meters (45.5 ft.) at high water.

Southampton and Dover afford only 12 meters (39.4 ft.) in depth at low water, and the navigable waterway at Hamburg is to be dredged to 12 meters (39.4 ft.) below high tide.

Without dwelling upon the fact, which he might have done, that the motor boat, by reason of economy in weight and space of machinery and fuel, will increase the efficiency of the vessels of whatever size in which used, and will thereby be in some measure a restraining influence upon the rate of their growth, the author expresses his confidence in the petrol motor and its adaptability for use on seagoing vessels of large size.

The author refers to the obvious disadvantage under which harbors at some distance inland, which must be reached by river or canal, compete with the seaports on the shore line. In some respects the maritime harbors which are made accessible by canal

may be considered better off, he says, than those located on rivers because it is nearly always possible to secure the necessary canal dimensions, while it may be difficult to accomplish and maintain the desired result in a large river.

Mr. Leemans would be taking an advanced view when he expresses his conviction that it is an undeniable necessity for a maritime nation, such as Holland, to have at least one port which is accessible to the largest vessels of the present or of the near future, if he did not qualify his statement to this effect with the clause, "if it may be assumed that such vessels will call at the port in question."

That it is desirable that each maritime country should have such a port will probably be conceded by all. It is equally true that this is a condition not easily realized if the dimensions of the largest vessels continue to increase as in the past. The fact that the securing of ports of practically unlimited draft in every one of the important maritime countries is out of the question is one reason why some limit to the increase in draft of the largest vessels should be set other than a limit determined only by the needs of commerce or by structural limitations, or by economy of operation and like considerations.

In this connection Mr. Leemans points out that the financial results of operating the large vessels are not always satisfactory. Government aid in the form of subsidies or otherwise is necessary. No reliable returns are available to demonstrate the unsatisfactory results of operating the largest type of vessels, but it seems probable that without government aid in the past there would have been a much less rapid rate of increase in dimensions.

Mr. Leemans believes that special consideration should be given to the vessels built with large freight capacity and for moderate speed, 16 to 19 knots. Within another fifteen years he thinks we may see on the Atlantic vessels of a gross tonnage of 70 000 to 75 000 with a draft of 12.5 meters (41 ft.), and he ventures to prophesy the economic and technical possibility of vessels 1 500 ft. (458 meters) long and 160 ft. (48.8 meters) beam, having a draft of 14.5 to 15 meters (47.6 to 49.2 ft.).

Mr. E. I. Zamjatin refers to the increasing size of vessels as demonstrated by the size of those visiting Russian ports as well by reference to vessels in general. The conclusion is reached that the maximum rate of growth has been passed. This is in part attributed to such financial disturbances as those of 1901–04 and 1907–09, and in part to the fact that small owners — as

distinguished from large aggregations of capital — are finding it profitable to enter the transportation field. The man of small capital must necessarily content himself with vessels of a more modest type than *Lusitanias* and *Mauretanias*, and his activity holds down the average size that might otherwise be expected.

The suggestion is also made that the risk of inadequate business increases with the size of the vessels. It is admitted, however, that these premises do not justify any positive conclusion, that the falling off in the rate of increase of size will continue, nor that any decrease of average tonnage of vessels is to be expected.

Mr. Zamjatin refers to the fact that the purpose of the increasing size of vessels is to reduce freight rates. The reduction in the cost of transportation decreases with the size of the ship because the freight capacity in its relation to dead weight increases with the gross tonnage, and because the operating expenses decrease with the increasing size. For purposes of comparison he makes the weight of machinery and fuel proportional to $D^{\frac{2}{3}}$ where D represents the displacement. He estimates that increase in the gross tonnage from 5 000 to 10 000, for vessels making 5 000 miles at a speed of 12 knots, should reduce the weight of fuel and machinery by $3\frac{1}{2}$ per cent. of the net tonnage, and the weight of the body of the vessel by 1 per cent. of the net tonnage. At higher speeds the reduction of weight of machinery and fuel will be still greater.

The conclusion is emphasized by Mr. Zamjatin that the relative decrease of power and the corresponding decrease of fuel required is the chief source of profit to the owner resulting from the increase of size. He might well have taken into account, too, the risk of loss or at any rate of lessened profits due to the fact that vessels do not always carry full cargo and are not always in continuous service.

Mr. Zamjatin draws particular attention to the value of the internal combustion engine in comparison with steam engines for the propulsion of large vessels. He believes that the steam engine will be displaced. The utilized caloric energy of the internal combustion engine is given at 37 per cent., as compared with 17 per cent. for the steam engine. Boilers and stokers are eliminated. The mileage of the vessel equipped with an internal combustion engine is given at four to six times the mileage of a vessel propelled by steam. The weight of the fuel required will be one fourth to one sixth of the former when compared with the latter. The weight of the machinery will be only one half. The

cost of fuel, too, will be only about one half [taking naphtha at 30 roubles ($23.83) per ton — the price at St. Petersburg] and about 67 per cent. to 57 per cent. of the cost of fuel for steam if the average price of oil in the world's market be introduced into the calculation.

In tabular form a comparison is given between vessels of about 9 000 tons — two equipped with steam engines and two equipped with "Diesel motors." At speeds of 12.5 knots he finds the carrying capacity of the vessel using Diesel motors to be 67 per cent. of the displacement, to be compared with 49 per cent. for the vessel equipped with steam engines. At speeds of 18 knots the former should have a carrying capacity of 58 per cent., as compared with 26.5 per cent. for the latter.

The operating expenses, including 3 per cent. for depreciation and 10 per cent. for interest and profit, are given for the lower speed at 60 500 roubles ($48 000) per annum for the Diesel motor boats and at 76 900 roubles ($61 000) for the steam boats, and for the 18-knot boats at 78 370 roubles ($62 200) for the former and 101 100 roubles ($80 500) for the latter.

Based on an equal percentage of profit, Mr. Zamjatin concludes that at 12.5 knots a Diesel motor boat of 14 000 tons may compete successfully with a steam boat of 21 000 tons, and at 18 knots a Diesel motor boat of 14 000 tons may compete with a steam boat of 36 500 tons.

Remarks and Conclusions.

No evidence was found and none is presented in the papers here reviewed which would indicate that for the present any other consideration than the demands of commerce and the willingness of the traveling public to pay for room, comfort and luxuries, and the ability of the shipbuilders to build the ships, will set a limit to the size of the ocean liner. In other words, if the deepening of the harbors and of harbor approaches is continued without restriction, the size of the largest ocean liners will, under otherwise permanent conditions, continue to increase.

Without any restrictions upon the size of vessels, they will be built constantly larger as demanded by economy of operation and by the needs of commerce, and only those ports can hope to be favored with the visits of the largest vessels which find it worth while to afford suitable harbor facilities.

The growth of vessels, therefore, exerts a strong influence upon the concentration of the export and import business at certain points, such as New York harbor, where nature has made

possible the construction of the facilities demanded by the ship-owner who wants to operate the largest boats that can with safety and without delay be taken into and out of the best harbors on the two sides of the Atlantic.

It follows from this that the port which is less favored by natural conditions is interested in having some artificial limit set to the size of the ocean carriers, particularly in the matter of draft, in order that harbor improvements may be planned with reasonable certainty that they will be adequate.

There should be an international agreement entered into that some depth of water at low tide is the standard to which the important harbors of the world will be improved, and there should be no government aid in the form of subsidy or otherwise to vessels whose dimensions are such as to make the entrance into a harbor of standard depth impossible.

It would be unwise, for example, for the United States to construct or to encourage by subvention or otherwise the construction of vessels too large to pass through the locks of the Panama Canal.

The usefulness to the government in time of war of a vessel depends upon its adaptability to the momentary requirements. It should be large enough, and yet not of such colossal dimensions that it cannot make port at some unforeseen new destination.

By the construction of the Panama Canal, a stupendous undertaking, the United States has practically set an upper limit for the dimensions of vessels whose construction can be encouraged by this government. The canal and the lock system on the canal have cost too much to be readily modified. For the time being the usable lock length on this canal of 1 000 ft., the breadth of 110 ft. and the depth of 41.5 ft. on the sills of the lock gates, equal to 40 ft. in salt water, or to 12.2 meters, has fixed the maximum dimensions both of war vessels and other vessels that are likely to be constructed by the United States or by American owners under government aid.

But if standard maximum dimensions for the largest desirable seagoing vessels be thus set by the United States, or by an international agreement participated in by the important maritime nations, this will not set a limit to the further improvement of shipping. There is room for improvement even when the limit of size has been reached. The internal combustion engine for example is full of promise and may, as forecast by Mr. Zamjatin, be of material aid in increasing cargo capacity. The gain in cargo capacity resulting in the use of internal combustion engines

would, moreover, be of particular value because it is obtained without an increase in displacement. So, too, in the matter of speed, there need be no limit set, unless for subsidized vessels it be a lower limit. If the reduction of weight of machinery and of fuel in the motor boat compared with the steamboat even approaches the figures given by Mr. Zamjatin, there should be ample opportunity for securing high speed without being compelled to give the vessels abnormal dimensions.

It remains to be stated that the largest vessels on such special routes as the one between New York and European ports stand apart in a class by themselves, and their dimensions need not be taken into account in forecasting the dimensions of the vessels for whose use the great maritime canals such as the Suez Canal and the Panama Canal and other canals of the first rank are constructed.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by December 15, 1912, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPERS, "FLOOD PROTECTION FOR MISSISSIPPI VALLEY."

(VOLUME XLIX, PAGE 52, SEPTEMBER, 1912.)

MORRIS KNOWLES (M. AM. SOC. C. E.). — The great, country-wide public interest in this most important question, and the numerous references in the original articles to the work of the Pittsburgh Flood Commission, with which the writer has had the honor and pleasure of being connected, are the reasons for his responding to the general invitation of the Secretary, in the September JOURNAL, to present a discussion.

All of the papers indicate the same sort of academic views with which Pittsburgh has been familiar for over sixty years. And it was only by interested people's digging down into their pockets and raising the necessary money that a change was brought about, and that discussion of evidence, founded upon actual surveys and definite information, took the place of idle talk with no data in hand. Captain Sherrill's statement that the use of reservoirs to prevent floods is one of the plans which are suggested as something new each time a big flood occurs, and which "on examination will be found to have been carefully considered and thoroughly investigated years ago" is incorrect; for all prior consideration has been of the theoretical type, from the office point of view and never from actual surveys. The Pittsburgh Flood Report is the first one based upon careful and accurate outdoor studies in full detail.

So great was the prejudgment in favor of local methods of protection, instead of drainage area means of prevention, that, for a long time, even after the Flood Commission studies and investigations were authorized, public utterances were against the expenditure of much of the money upon reservoir surveys. On the other hand, the sole, but persistent, request of close students of this problem was that a thorough investigation be made, based upon ample surveys and data. The same insistence should be repeated with regard to the more serious problem of devastation by the "Father of Waters." The desire for a thorough-going study ought not to be stifled; the attempt to gain a full knowledge of the facts must not be thwarted by

continued harping on inherited prejudices based upon little or no information.

It is evident from the remarks of Mr. Frank M. Kerr, upon pages 93 and 94, that the desire of some is for national money to use as local ideas may dictate and not as a great central government may decide is best for all the people. He says:

"Aid must be had, and that aid, in the natural order of things, must come from the federal government. But it should come to us upon a direct, segregated basis, comprehending immediate expenditures for the accomplishment of practical results necessary to the protection of the valley from overflow, within a reasonable lapse of time, not coupled up with propositions, coördinate to some extent, but not necessary to the accomplishment of that which we, first and foremost, need ourselves, — levees. Any other course must, in my opinion, indefinitely defer, if it does not altogether defeat, our chances for aid.

"It may be all very well for those interested in propositions far removed from our borders, to come amongst us and sing in dulcet tones that might, under most circumstances and conditions, tend to "soothe the savage breast, to soften rocks, or bend a knotted oak," about conservation, reservoirs, power, irrigation, drainage, river control, and all that may follow in the wake of each combined, to be, in the dim and distant future, harnessed together into one grand vehicle of munificence and power, to convert our valley into an elysium of safety, progress and prosperity, but the federal government is slow, very, very slow, to be lured along such lines, all in a bunch, as it were, and the effort must sooner or later prove abortive through the evidence of its own utter impraticability of accomplishment within any time profitable to the present generation.

". . . Federal aid cannot too soon be secured and accorded. Federal aid and federal control, however, are two very different propositions."

In other words, "Give us the money and let us alone dictate how it shall be spent." I venture to say that our National Government is not going to do this.

As all of us, all over this broad land, come to understand that preventing floods, irrigation of arid lands, making for better supply of water in the summer and autumn for power, navigation, domestic use, etc., are all part of one great and comprehensive national problem, we shall view with better grace and understanding the sinking of our own pet whims and schemes in the solution which will bring the greatest good to the greatest number. Some of us believe that the machinery for studying and carrying out such an excellent national program is admirably provided for in the Newlands River Regulation Bill, which is evidently the brunt of the veiled sarcasm quoted in the second

paragraph above. Some of us believe that immature local solutions of problems involving large national consequences have been the bane of our rapid American development, and that the time is now here when such hasty action in all parts of the country should give place to wisely considered, harmonious, national action.

While it is true that nature seems to have done poorly in providing the flow of the streams with regularity and when most needed, it must be remembered that man himself has done much to intensify and aggravate conditions which cause floods. One has only to recall the devastation of forests and upland slopes and the encroachments upon width and area of channel-ways to realize that our doings have contributed in a large measure to our troubles. Throughout the whole world's history, deserts and rivers have held uncontrolled sway in their respective realms. This and subsequent generations must determine whether they shall so thoroughly and comprehensively study and solve the mighty problems of watering the arid wastes and preventing devastation by rivers that desert areas and fertile valleys alike may be made more safely habitable.

The mention of influence of forest cover recalls the similarity of Prof. W. B. Gregory's paper to the usual plaintive wail that facts quoted by eminent authorities do not bear out the assumption that forestation affects stream flow, except in some cases "to increase it." One does not need this sort of proof to realize that, even in a small backwoods lot, cutting of the trees is soon followed by gullying of slope, denuding of vegetation, quicker run-off from rain storms and, frequently, drying up of previously dependable springs. Such illustrations are too common to ignore.

The reference to the admirable work of the United States Geological Survey is passed over with scant courtesy. Here are data collected for the first time, from an intensive study under conditions of accurate control and knowledge of the variables. The result should convince the most skeptical.

These studies covered the months of February, March and April, 1912, and were made for the purpose of showing to the National Forest Reservation Commission whether any direct relation existed between forest cover and stream regulation. One drainage basin had 80 per cent. of the area covered with virgin forest; the other, of about the same area, had been entirely cut over and subsequently burned. Other conditions were in all respects about alike. During three April storm periods,

the rate of run-off on the former averaged 56 per cent. of that upon the latter; the maximum flood flow was also only 61 per cent. on the first of what it was on the second. The report concludes as follows:

> "The particular case . . . is typical . . . and establishes the general conclusion that a direct relation exists between forest cover and stream regulation. . . . The removal of forest growth must be expected to decrease the natural steadiness of dependent streams during the spring months at least."

The paper by Capt. C. O. Sherill bears the earmarks of an attempt to prove what one has for a long time believed, irrespective of what new evidence may show. Else why should the data and statements of the Pittsburgh Flood Commission be so misinterpreted and perverted from their true intent? That the writer has had some small part in the framing of this report is sufficient reason for pointing out a few of these inaccuracies, and he trusts that in these instances he may thereby present the proper interpretation.

In the first place, reasoning from the suggested proportion of area controlled, per cent. covered by storage reservoirs, and like generalities is a fallacious and dangerous method. It is idle to talk about relative areas controllable on other large streams, without the intensive and accurate studies so necessary to correct conclusions. No one has ever claimed that one third of a drainage basin must be covered by water surface, as is the case of the Niagara River; topography, probability of effects on floods from given watersheds, depth and capacity of possible reservoirs, — all have a most important bearing. Careful reading of the Flood Commission's report will show also that it is not necessary to store all of any or of all floods, but only the peaks of certain ones. Again, some tributary streams appear to be repeated offenders; others, even at their highest stages, may not deliver their flood waters to the big stream below at the usual time of peak discharge there. This is the reason for choosing seventeen out of forty-three studied sites on the Allegheny and Monongahela drainage basins, because of their higher rating in "Relative Value of Effectiveness"; the others were not, as Captain Sherill has said, "accordingly thrown out of consideration, as being impracticable."

It should be pointed out, too, that the reference to the "fifteen next practicable dams" is distinctly misleading. These fifteen dams were undoubtedly the "next practicable" ones

surveyed by the Pittsburgh Flood Commission. But to imply that they were the next practicable ones in the drainage basin, when the commission's report shows clearly that the reservoir possibilities above Pittsburgh were not exhausted, for the obvious reason that sufficient capacity was found without necessitating further expense for surveys, is unfair.

The statement that "no study of the effect of floods . . . was made by this Commission . . . on the Ohio, except as incidental to this study of local flood conditions at Pittsburgh," does not relate the whole story. The following is taken from the published report.

"It is shown that the greatest recorded flood at Wheeling, W. Va., — that of 1884, — would have been reduced 13 ft. and that the next greatest flood, that of March, 1907, would have been reduced 14.5 ft. . . . At Wheeling, the low water discharge could be maintained at three times the present minimum, corresponding to an increase in stage of 2.3 ft. . . . A similar solution of the problem on other tributaries of the Ohio would extend flood relief throughout the entire valley."

The references to Captain Chittenden's and Mr. M. O. Leighton's reports are equally misleading. The former actually stated;

"It is probable, however, that in all the watershed of the Mississippi sites could be found that would insure a reduction of flood discharge at Cairo, like that of 1897, by one fifth of its maximum."

And, in another place,

"The ease with which the writer was able to find storage amounting to eleven billion cubic feet in the state of Ohio at the very head waters of streams along the divide between Lake Erie and the Ohio convinced him that the *natural facilities for storage are rather greater than is commonly supposed.*"

Captain Chittenden was worried, however, about the expense, compared to the benefits to be obtained, and this should always be thoroughly and wisely considered; always bearing in mind the many collateral advantages that come from stream regulation. The benefits, even with increased cost of construction, are fast growing relatively greater, as the country becomes more densely populated. Millions for preventive works, also, are less enormous by comparison and less difficult to raise than when the country was younger.

Mr. Leighton's report and estimates instead of being disproved were, to a very large extent, verified by the more detailed and intensive work of the Pittsburgh Flood Commission. That reservoir capacities do not agree in all cases is not a surprising thing to those who have first planned from the excellent, but general and relatively small-scale, government topographical maps. That the Flood Commission recommends less storage in some cases does not indicate that more is not possible, but simply that more is not needed at this site for the particular purpose of storing the peak of the flood flow. In fact, the Commission's report states that more storage is possible in nearly all cases and could wisely be developed, for the additional advantages of furnishing power, or water supply for cities, or for navigation, or for all such purposes. That the published report of the Flood Commission does not disagree with Mr. Leighton's conclusions is apparent from the fact that he reviewed it for the consideration of the National Waterways Commission, and approved of the findings and conclusions of the Pittsburgh report.

The 14-ft. levee, so called by Captain Sherrill, is not needed to keep out ordinary floods at Pittsburgh, if the reservoir system is built. It is really a concrete quay-wall that is recommended, and this only for a short stretch around the city at particularly low points. All floods, except one like that of 1907, which occurs once a century, would be lowered below danger by the seventeen reservoir system. Even a "forty-foot flood" would be kept within bounds by the use of both reservoirs and wall. As the wall (not a levee) is of concrete and extends down into the ground, it will cut off excessive seepage, provide a large hollow section for an intercepting sewer and, most important of all, will afford shipping and terminal facilities which are so sadly needed at all American river ports. It is particularly for this latter commercial and business reason, as well as for affording relief from overflow, that Pittsburgh will vote in November on a $900 000 bond issue for this purpose. Pittsburghers firmly believe in the recommendation of the National Waterways Commission and of the recent 1912 Rivers and Harbor Bill, that cities which desire national appropriations for river improvement shall show their faith, not only by helping themselves by local expenditures for improved facilities, but by coöperation in aiding a national program.

Captain Sherrill's remarks, reflected somewhat in the other papers, about the insecurity of dams and danger from breaking, by the very references to the mud bank at Johnstown, and to the

inadequately foundationed dam at Austin (not, by the way, "reinforced concrete") as "the best types of earth or concrete construction," argue his lack of familiarity with the great water supply and flood control works abroad, and the more recent, but equally important, dams, sometimes even greater in magnitude, of the United States Reclamation Service; those upon which the water systems of Boston, New York and other lesser cities of this country depend. Dams have failed. Yes! And they will as long as their design or construction by the inexperienced or the parsimonious is permitted without control. But the great modern structures, now being built, many of them by the United States, show the foolishness of any such specious plea. Why can we not look at this matter as we do at other engineering failures? Do we fear to erect and use bridges because the Quebec bridge failed? Have we abandoned the use of railroads because each week brings its news of accidents and casualties? Has the frightful disaster of the *Titanic* destroyed our faith in steamships as a mode of travel? Decidedly not! Another bridge is being erected at Quebec. Railroad traffic continues to increase from year to year. Even larger steamships than the *Titanic* are being built in the shipyards of Europe. In these matters we do not disregard the thousands of examples of successful accomplishment, as we are asked to do by the opponents of reservoirs.

Equally novel but unsound is the idea that "the wide fluctuations of the water surface of reservoirs" would be a "menace to health." That this is not so, the numerous reservoirs all over the country, used for domestic water supply and frequently filled and emptied, bear unassailable evidence.

The Pittsburgh Flood Commission, the advocates of its policies and the friends of the Newlands River Regulation Bill do not, for one instant, advocate that there is any one and sole solution for this flood problem or for any other great question, national in its scope, and with so many variables. That this is also true of at least one speaker at the Louisiana Engineering Society's meeting is evident from a perusal of the paper by Mr. Arthur M. Shaw. The contradiction of two statements, one early in the paper and the latter at its conclusion, is apparent. He says:

"In most reclamation plans, no cognizance is taken of possible overflow from the Mississippi River, and this is as it should be, for if we were to provide levees of sufficient height and strength to keep out all possible crevasse water, the funds

for land reclamation would never become available. Land values have not yet reached the point that would justify this extravagant method of protection. Fortunately, such excessively high levees are not required. The occasional floods, disastrous as they are, do not even now come with sufficient frequency to cause the abandonment of any otherwise worthy reclamation project, and in spite of the discouraging and disheartening experiences which many of them have just passed through, we may expect to see the people returning to their lands, as the waters recede.

"... It is apparent that those owning or living on the reclaimed lands of the valley have little personal interest in the exact method used to control the river, but it is hard to see how their interest can better be safeguarded than by the early construction and proper maintenance of a system of levees which will be of ample height and cross-section to hold in place the Father of Waters."

This is also shown by the telegram sent broadcast over the country by the New Orleans Flood Relief Committee and Progressive Union. It is as follows:

"New Orleans, because of its peculiar defensive strength, is the safest city in the Mississippi, Ohio or Missouri valleys, despite the fact that Louisiana must protect herself from the flood waters of some thirty other states. This should be the duty of the national government by a broad and sane system of conservation at the head waters, such as contemplated in the Newlands River Regulation Bill. . . . Louisiana has spent fifty millions of dollars out of the public treasury, and private individuals and railroads millions more for levee protection, since the Civil War. We earnestly urge the citizens of the United States, and particularly the newspapers, to give us the only outside aid we ask; that is, discredence of false and alarmist stories and support of the Newlands River Regulation Bill, which will harness the floods and force them to serve instead of to destroy."

The resolutions adopted May 14, 1912, by the Louisiana Reclamation Club, and those adopted June 6, 1912, by the senate and house of the Louisiana legislature, effectively show the existence of a desire for a broad and comprehensive consideration of the problem, such as will come from national control of large rivers and never from local protection schemes.

The advocates of a broad national policy do not say that levees are not of advantage, or that they may not be a very necessary protection in some places, particularly upon portions of a river of changing banks and bed; nor do they say that walls may not be of great collateral benefit at Pittsburgh, although

with sufficient reservoir capacity they may be entirely unnecessary for flood protection alone; but they do say that many of the errors of the past have come about from a false idea of solving local troubles without reference to the broad and country-wide effect. It is time that such wasteful expenditure of money should cease. No urgent immediate need should longer be an excuse for putting off the adoption of a national program for these questions.

Much good can certainly be accomplished by such a thorough survey and investigation as was made for Pittsburgh; and advocates of a levee system have no reason to fear it. If this were done, all academic discussions would be ended.

The people of the Mississippi, Ohio and Missouri valleys will do well to unite with those desiring better navigation facilities, drainage and reclamation of swamp lands, watering of arid wastes, creation of power, etc., so that a united national front may be presented in the fight for the Newlands River Regulation Bill.

That the opinions, recommendations and conclusions of the Pittsburgh Flood Commission may not be misunderstood by any statements in the papers, I have taken the liberty of repeating them here, where they may be seen for reference when reading any of the articles referred to.

"The investigations and surveys of the Food Commission, and studies based thereon, as fully described in the succeeding chapters of this report, enable the Commission to make the following statements:

"1. Floods are increasing in frequency and height.

"2. There is every probability that Pittsburgh will some day experience a forty-foot flood.

"3. The damage resulting from a flood of a given height is steadily increasing.

"4. The direct losses due to flood damage at Pittsburgh amounted to over $12 000 000 in the last ten years, while in one year and five days, between March 15, 1907, and March 20, 1908, three floods occurred, causing a direct loss at Pittsburgh of about $6 500 000.

"5. If works for flood relief are not carried out, the direct losses due to floods damage at Pittsburgh alone will, on a conservative estimate, amount to $40 000 000 in the next twenty years.

"6. The flood losses along the Ohio valley in one year, 1907, are stated in the preliminary report of the Inland Waterways Commission for 1908 to have amounted to over $100 000 000.

"7. Flood relief by some form of local protection only, *without storage reservoirs*, cannot be recommended because:

"(*a*) Such protective measures would give local relief only.

" (*b*) Such local relief would be the only benefit derived.

" (*c*) Dredging alone, without reservoirs, would not reduce floods sufficiently, and a wall would still have to be built.

" (*d*) The wall, without reservoirs, would have to be too high and would be too costly.

" 8. The flood water that would otherwise cause damage can be impounded in storage reservoirs, and by this means floods can be prevented.

" 9. There are many favorable reservoir sites of large capacity available for flood water storage on the drainage areas above Pittsburgh.

" 10. Forty-three sites have been selected and most of them completely surveyed by the Flood Commission, the others having been studied from existing topographical maps and by means of partial surveys.

" 11. From a study of the relative effectiveness of the various projects it was determined that adequate flood reduction at Pittsburgh could be obtained with 28 of these reservoirs, while a final analysis reduced the number to 17.

" 12. *If the Seventeen Selected Reservoir Projects* had been in operation, without any wall, the storage of flood water in these reservoirs would have reduced all past Pittsburgh floods to below the danger mark, or 22-ft. stage, with the exception of the great flood of March, 1907, which would have been reduced from a stage of 35.5 ft. to a stage of 27.6 ft.

" 13. Supplementing the Seventeen Selected Projects by a wall along the low-lying portions of the river bank would confine all floods, *including a possible* forty-foot flood, within the river channels.

" 14. Flood prevention by storage reservoirs is possible and practicable, and is recommended because:

" (*a*) The flood relief would be extended over hundreds of miles of tributaries and of the main rivers, including the Ohio for many miles below Pittsburgh.

" (*b*) The impounded flood water, with proper manipulation of the reservoir system, would considerably increase the low-water flow of the tributaries and of the main rivers.

" (*c*) This increased low-water flow would greatly aid navigation and interstate commerce.

" (*d*) The increased low-water flow would notably improve the quality of the water for domestic and industrial purposes.

" (*e*) The sewerage problem of Pittsburgh and of many other communities along the rivers would be simplified.

" (*f*) The public health would be protected against the dangers arising from the unsanitary conditions caused by overflow and by extreme low water.

"(*g*) A considerable amount of water power would be incidentally developed.

"15. The solution of the flood problem therefore becomes of great importance to other communities along the river, and to the counties and the state, and also, because of the benefits to navigation, to the National Government.

"16. Reservoirs for flood control have been built in other countries, and have been so successful, both in preventing floods and improving the low-water flow and navigability of the rivers, that other large works of this kind are now under construction, and many more are contemplated.

"17. Prevention of Pittsburgh floods by storage reservoirs has in the past been pronounced possible by a number of eminent engineers. It has generally been thought impracticable because of the cost, but these opinions as to cost were not in any case based on actual surveys, designs and estimates.

"18. The estimates of the cost of storage reservoirs and other works for flood relief made by the Flood Commission are based on detailed surveys, and show that Pittsburgh can be completely safeguarded against floods at the cost of about $20 000 000.

"19. The Commission urges the carrying out of the proposed works for flood relief at the earliest possible date. The expenditure of this sum of $20 000 000 is warranted for the following reasons:

"(*a*) Had this expenditure been made, so that the benefits therefrom would have been realized through the past ten years, more than half the amount would have been saved by prevention of the flood damage at Pittsburgh alone.

"(*b*) The cost is but one half the direct loss, amounting to $40 000 000, that it is estimated will otherwise be caused by flood damage at Pittsburgh in the next twenty years.

"(*c*) The cost is small considering the total loss by flood damage in a few years, in all the districts that would receive benefits from flood relief.

"(*d*) The flood losses along the Ohio Valley in one year, 1907, are stated to have amounted to over $100 000-000. The proposed reservoir system would completely relieve the upper Ohio from damaging floods, and reduce their height and damage for a considerable distance downstream.

"(*e*) The expenditure of the sum necessary upon the Allegheny and Monongahela rivers would be the important beginning of the construction of a comprehensive reservoir system upon all tributaries of the Ohio River. Such an extension of the system would prevent floods throughout the entire Ohio valley.

"(*f*) The reduction of the maximum and the increase of the minimum flow of those streams that are now navigable for any portion of the year, would greatly increase the traffic opportunities upon them. At the maximum height, the current would be greatly reduced, the clearance under the bridges increased, and access to landings easily obtained. During the lowest stages there would be sufficient depth of water for vessels of ordinary draft.

"(*g*) The annual saving due to the improved quality of the water for domestic and industrial uses, and the prevention of damage resulting from chemical impurities in the water, at low stages of the streams, would, in itself, warrant an expenditure of a considerable portion of the cost of the proposed flood prevention.

"(*h*) The large area affected by floods in Pittsburgh includes real estate having an assessed valuation of $160 000 000. If relieved from the flood menace, this property would be increased in value at least $50 000 000, or more than twice the cost of the necessary flood relief measures.

"(*i*) The water power that would be developed could be utilized to produce electric energy, and would yield a revenue that would cover the cost of maintaining and operating the reservoir system, as well as rendering a return upon the investment."

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Engineers' Club of St. Louis	January 5, 1881	369
Boston Society of Civil Engineers	January 19, 1881	834
Civil Engineers' Society of St. Paul	December, 1884	54
Montana Society of Engineers	April, 1888	138
Technical Society of the Pacific Coast	March 1, 1895	97
Detroit Engineering Society	January, 1897	278
Louisiana Engineering Society	September 15, 1898	171
Utah Society of Engineers	August 5, 1908	94
Oregon Society of Engineers	October 26, 1911	188
Total		2 223

THE ASSOCIATION AND ITS JOURNAL.

The Association of Engineering Societies exists for the purpose of securing the united action of various engineering societies and clubs, and has the same reason for its existence that any local club has for its existence, to wit: the comparison of different views, and the benefit to the profession by combined effort. The information with regard to engineering in different parts of the country is brought together by the joint action of the societies, and an opportunity, at least to that extent, is provided for professional coöperation. It has always been the hope of the promoters of the Association that still further benefits in the way of united effort should be obtained. The papers which have been published in the past sufficiently illustrate the value of this combination, as, for instance, frequently making known the peculiar engineering problems incident to some locality, and the successful solution of them, to the engineers of other localities.

It is believed that by the accession of more local societies to the Association, a greatly enlarged benefit of this character might be secured, both by the new-comers, and by those already members of the Association, and that the improvement which it is thought might be expected in the literary contents of the JOURNAL would also promote its success by making it more desirable for subscribers who might not be connected with any of the local societies.

ASSOCIATION

OF

ENGINEERING SOCIETIES.

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VOL. XLIX. DECEMBER, 1912. No. 6.

THE REINFORCED CONCRETE COLUMN.

BY CARL GAYLER, MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, October 2, 1912.]

THE well-known formula for the strength of reinforced concrete columns reads as follows:

$$P = f_c C + n \times f_c A \quad \ldots \ldots \ldots \ldots \quad (1)$$

where P is the safe load in pounds;

f_c = allowed pressure per square inch of concrete in pounds;

n = ratio of modulus of elasticity of steel to that of concrete;

C = area of core of concrete in square inches; and

A = aggregate area of longitudinal steel reinforcement in square inches.

The formula is simple and logical. The permissible unit pressure on the concrete, deduced from the great number of tests made in this and foreign countries, is the governing factor of the strength of a column of given design, the unit pressure on the steel being chosen so as to obtain equal deformation under loadings for both materials. No allowance is made for any compressive resistance of the shell of the concrete.

Further study of the full size tests which are already available and future tests may modify the unit stress for the concrete, but the formula is too clearly based on common sense and sound scientific principles to be lightly discarded. An ideal formula for reinforced concrete columns is even less to be hoped for than an ideal formula for iron or steel columns.

For the last fifty years the engineering profession has been wrestling with the latter problem; we have all waded through reams of printed matter full of Euler, Gordon, Rankine, straight line formulas, formulas for straight end-, pin-bearing ends, etc., and the end is not in sight and never will be.

In one respect only a modification of formulas for the strength of reinforced concrete columns seems to be desirable, i. e., in taking account of the ratio of length to diameter.

In designing a column according to formula (1), it is of great importance that the longitudinal rods are clamped together at short vertical distances by steel bars, as each one of the longitudinals for the distance between the clamps forms a free steel column under vertical pressure from the loads and under lateral pressure from the concrete.

The reasons for considering the longitudinals as free columns are that little or no reliance can be placed on the outer shell of concrete to resist lateral pressure, and that the core in hardening is liable to contract sufficiently to break the bond with the longitudinal rods.

The building laws of our city specify on this point as follows: "These longitudinal members shall be stayed against buckling at points whose distance apart does not exceed twenty times the least lateral dimension of the longitudinal members."

Under this ruling ¾-in. rods should be stayed at distances not exceeding 15 in., 1-in. rods at distances not exceeding 20 in. These permissible distances are far too great; the maximum distance for any size of rods should not exceed 6 or 8 in.

The latest and best type of reinforced concrete column, however, is the "hooped column" where closely spaced steel spirals take the place of the above-mentioned clamps.

Hooped columns without longitudinals are not considered in this paper. Their strength in short lengths is very great, but for columns of ordinary lengths, or exposed to eccentric loads, their working strength is unreliable.

Now for the hooped column with longitudinal rods we find the following rule in the building ordinance of St. Louis:

"If a concrete column is hooped with steel near its outer surface either in the shape of circular hoops or of a helical cylinder, and if the minimum distance apart of the hoops or the pitch of the helix does not exceed one tenth the diameter of the column, then the strength of such a column may be assumed to be the sum of the following three elements:

1. The compressive resistance of the concrete when stressed

not to exceed 500 lb. per square inch for the concrete enclosed by the hooping, the remainder being neglected;

2. The compressive resistance of the longitudinal steel reinforcement when stress does not exceed allowable working stress for steel in tension;

3. The compressive resistance which would have been produced by imaginary longitudinals stressed the same as actual longitudinals being taken at two and four tenths (2.4) times the volume of the hooping."

Expressing the above algebraically so that the man who runs may read and understand it, we find that the safe load P in pounds of a hooped column as prescribed by law

$$=500C+f_s(A+2.4\times\frac{12}{m}\times\pi d\times A_1) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where C is again area of core of concrete in square inches;

f_s = working tensile stress for steel per square inch;

A = aggregate area of longitudinals in square inches;

A_1 = area of cross-section of hooping in square inches;

2.4 = a constant;

m = pitch of coil in inches; and

d = diameter of coil in feet.

$\frac{12}{m}\times\pi d\times A_1$ would, then, represent the volume of the so-called "imaginary" longitudinals.

This rule is a paragraph of Section 198 of the Reinforced Concrete Ordinance prepared by a special committee of our Club and passed by the Municipal Assembly some years ago. It is the formula evolved by Mr. A. Considère of the École des Ponts et Chaussées, Paris, from his numerous remarkable tests. The French government has adopted Mr. Considère's formula as the official rule for all reinforced concrete hooped columns or pillars, with one modification: 2.1 has been substituted in place of the constant 2.4.

At first glance the formula is startling; it seems so utterly irrational:

The allowed unit pressure on the concrete is very low. Allowing 500 lb. for the ordinary clamped columns as a safe load, we are certainly justified in stressing the concrete in a superior type of column, such as the hooped column undoubtedly is, to 700 or 800 lb. per square inch, particularly in buildings where no shocks from live loads are to be expected, as in bridges or viaducts.

That the longitudinals are under compression, at least up to the point where the column is in danger of bending, is beyond

a shadow of doubt, yet we find them stressed to the capacity of tensile members.

But most astonishing of all is the stress allowed in the spiral coil. That in its very nature this coil is unable to take up any appreciable vertical compressive force beyond the doubtful value of its bearing on the concrete shell is undeniable, yet we find these spiral rods credited with a strength of 2.4 times the high unit stress in the longitudinals.

A partial explanation of the seeming paradox is as follows:

The formula is a composite. As you see, its right side consists of three parts; the first of these (500*C*) is taken from statics, the third is taken from hydraulics, but what laws the product in the middle is taken from, I have to leave to wiser heads than mine. The hydraulic portion of the formula means that the lateral deformation of the concrete is resisted by the coil in exactly the same manner as a fluid in a cylinder under action of the piston. The coil thus acts in tension. In fact, we are not dealing with a formula in its ordinary sense at all, but with an algebraic expression in the shape of a formula, the results of which agree closely with the results of Mr. Considère's tests.

The expression " irrational " has been used in regard to the formula, and you may judge from the following whether rightly or not. The coil begins to act in tension the moment the concrete is so far compressed that appreciable lateral deformation takes place; in other words, any stress in the coil is transmitted through the concrete. Is it, then, not more logical to add the increment of strength of the concrete, obtained by virtue of its firm enclosure in the coil, to the stress allowed on the concrete, i. e., to go back to formula (1) and take a larger value for f_c?

To take an example:

The strength of a 24-in. column, core 20-in. diameter, longitudinals 8-in. rounds, spirals $\frac{3}{8}$-in. rounds with 3-in. pitch, is, according to formula (2),

=500 lb.×314 sq. in.+20 000 (6.3 sq. in.+2.4×4×3.14×1.7×0.11 sq. in.).

=157 000 lb.+126 000 lb.+112 000 lb.=395 000 lb., say, 200 tons.

You notice that the resistance of the concrete amounts to 157 000 lb., that of the steel to 238 000 lb., or over 50 per cent. more.

According to formula (1), allowing 500 lb. per square inch on the concrete:

$$P = 500 \times 314 + 7\,500 \times 6.3.$$
$$= 157\,000 + 47\,250 \text{ lb.} = \mathit{204\,250\ lb.}$$

Allowing 750 lb. per square inch on the concrete:

$$P = 750 \times 314 + 11\,250 \times 6.3 = \mathit{306\,375\ lb.}$$

Allowing 1 000 lb. per square inch on the concrete:

$p = 1\,000 \times 314 + 15\,000 \times 6.3 = \mathit{408\,500\ lb.}$, say, 200 tons.

Assuredly the above figures of formula (2), 157 000 lb., 126 000 lb. and 112 000 lb., do not represent the relative strength of the concrete, of the longitudinals and of the coil, yet their sum might be satisfactory; but another interesting point has to be cleared up first: *Does sufficient lateral deformation of the concrete take place to bring the coil into action before the safe limit or even before the yield point of the column is reached?*

By making the coil strong enough, we can undoubtedly crush the concrete to powder, and the coil, at least in a short column, might still carry the load. Such a column could hardly be called a reinforced concrete column, however, and you will all agree that no design of a column is admissible where the concrete under the assumed safe load of the column is stressed beyond the yield point.

Now Mr. Considère's theory is diametrically contrary to any such proposition; he claims that new qualities are imparted to the concrete inside the coil on account of lateral deformation being prevented by the opposed lateral resistance; that, in fact, the coil under action creates a new species of concrete.

Mr. Considère's claims are clearly and comprehensively expressed by Mr. Charles F. Marsh in his standard work on Reinforced Concrete as follows:

1. "Concrete not reinforced, or reinforced by longitudinals only, even when tied together by cross-ties spaced much nearer than is usual in present-day practice, will break by swelling under small deformations and without warning; while hooped concrete sustains without crushing considerably heavier loads, and only fails a long time after cracks in the surface and exaggerated deformation have given warning of the danger."

Clearer could the case in favor of the hooped column not have been expressed, and we can all subscribe to Mr. Marsh's

statement, but the question at what stage of the loading the beneficient action of the coil begins, is still left open.

2. "The application of a first pressure on a hooped prism, no matter how high that pressure may be, has the effect of raising its elastic limit up to that pressure."

This is clear and comprehensive enough, but to believe it calls for a faith in Mr. Considère's experiments equal to the faith that can remove mountains.

3. "The experiments [of Mr. Considère] showed that concrete which has been loaded when hooped has, after the removal of the spirals, a resistance which, after attaining a certain amount, remains constant, notwithstanding the increase of the deformation, at any rate within wide limits; and that the previous compression, while hooped, gives the concrete, besides a greater ductility, an increased resistance of 50 per cent."

4. "The flexure of a column is to be feared under high pressures. It is, therefore, unfortunate that the coefficient of elasticity, which is distinctly proportional to the column resistance, decreases with the increase of pressure under first application of the load; on the other hand, it is specially fortunate that hooped concrete, after having been subjected to a first loading, has a coefficient of elasticity which increases with the pressure."

(The numerals are the writer's.)

To illustrate sentence 4: In Fig. 2, a stress deformation curve of a concrete prism, plain or reinforced, is shown in full lines; the curve is downward, i. e., the deformation increases with the pressure; thousands of tests on all sizes of specimens have proved this conclusively. The dotted line, curving upward, would represent the stress deformation curve claimed by Mr. Considère for the hooped column.

Under the class of concrete under pressure and prevented from deformation by lateral pressure, we can to some extent include the concrete in the upper portion of an ordinary slab, more particularly of a double reinforced slab as shown in Fig. 3. In this case lateral deformation of any cubic-unit of the concrete produced by the action of one set of reinforcing bars is prevented by the action of the reinforcing bars at right angles to the former. Any doubts as to the overstressing of such concrete would, of course, be at once set to rest by accepting Mr. Considère's claims.

The writer would perhaps not have presumed to criticise a high authority like Mr. Considère, but for the following:

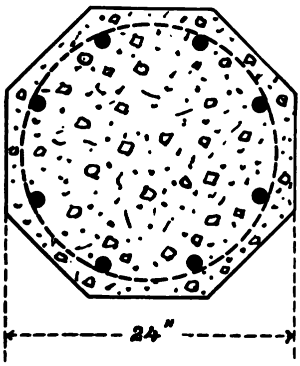

FIG. 1.

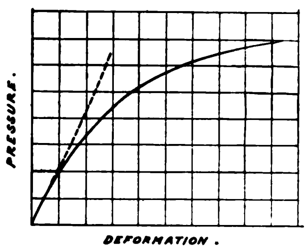

FIG. 2.

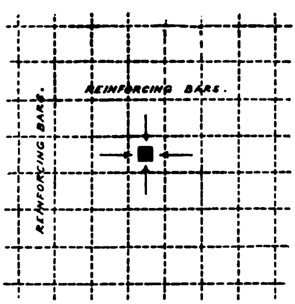

FIG. 3.

FIG. 4. FAILURE OF COLUMN J2.
Length 8 ft. 6 in.
Diam. of Core 10 in.

Eight or nine years ago tensile tests on reinforced concrete beams made by Mr. Considère and supported by tests of other investigators seemed to prove that the insertion of steel rods in the tensile portion of a beam or girder altered the very nature of the concrete. To quote again from Mr. Marsh: "That such reinforced concrete will bear very much greater elongation than has been thought without cracking, and under these elongations will still sustain its maximum resistance."

A member of our Club, deservedly prominent in reinforced concrete work, made at that time the statement that the whole science of reinforced concrete stands or falls by this theory of increased ductility of such concrete.

The tests made by Professor Talbot, Professor Turneaure and others soon disposed of the theory, our esteemed member was not slow in seeing the error of his ways, the theory is well-nigh forgotten and the so-called science of reinforced concrete still lives.

As to the advisability of adopting Mr. Considère's column formula, it should furthermore be taken into consideration that his tests were generally made on small specimens, his first twenty-six tests on mortar cylinders 1.6 in. diameter, hooped with fine wire, and that his coils consisted of mild or medium steel, as is the general practice in Europe. Now the reinforcing steel used here is generally hard steel stressed in daily practice to 20 000 to 22 000 lb. per square inch, which brings the unit stress in the coils up to 48 000 and 52 800 lb. per square inch.

In this connection it may be mentioned that American tests are more satisfactory than tests made in France or Germany because, as a rule, they are made on good-sized, well-proportioned columns, whilst, for instance, the careful tests of Professor Bach, of the Technische Hochschule, Stuttgart, which to some extent support Mr. Considère's claims, were made on columns one meter high.

The whole question is very serious. In the writer's opinion, the safe loads permissible under our building laws are too high, and in practice the aggregate area of the steel longitudinals is liable to be slighted in favor of the imaginary longitudinals. We see this in the column section shown in Fig. 1. If the designer had not taken the advantage offered by the allowed high stresses in the coil, the longitudinals would probably consist of ten or twelve in place of eight 1-in. rounds. Another important point is here to be considered. It is perfectly proper that in reinforced concrete columns formulas no account is taken of the

concrete in the shell, but a thorough bond between the core and the shell is necessary in order to get full benefit of the shell as a fire protection for the imbedded steel, and even a future increase of the thickness of the shell over the customary $1\frac{1}{2}$ in. is not at all unlikely. Now by increasing the size and reducing the pitch of the spirals, this bond might be endangered, and it seems advisable to prescribe a minimum pitch of the spirals of, say, $2\frac{1}{2}$ in. for $\frac{1}{4}$-in. or $\frac{3}{8}$-in. spirals.

Scientists deserve great credit for studying the laws derived from tests on columns or prisms of all sizes and under all conditions of loading, but the engineer is interested mainly in the behavior of columns of ordinary size and under probable conditions of loading or loadings not exceeding the yield point. A great deal of light has been thrown on such behavior by tests made during the last few years at our great state universities.

Professor Talbot, of the University of Illinois, states as the result of his tests on hooped columns as follows:

> " In hooped columns the hooping does not come into action to any great extent before a load equivalent to the ultimate strength of plain concrete or a little below is reached. The longitudinal deformation and the lateral deformation are not modified by the hooping to any great extent before this load is reached."

This seems to dispose pretty effectually of any practical value of Mr. Considère's formula.

Mr. Norton Owen Withey, assistant professor of mechanics at the University of Wisconsin, has recently made tests on over thirty hooped columns, and the conclusions which Mr. Withey has drawn are, in the writer's judgment, so far the last and most valuable word spoken on our problem. In Fig. 4 you see a picture of a hooped column in its final state under the testing machine. The picture is taken directly from Mr. Withey's pamphlet; it speaks for itself: If a reinforced concrete column, after developing its ultimate strength, instead of cracking all to pieces, presents the graceful bends of the column shown in our figure, we may feel secure that in the hooped column with properly spaced longitudinals we have a structural member on a par in reliability with any steel column.

The great value of Mr. Withey's tests lies in the fact that the columns were tested with a view of obtaining their comparative resistance under varying percentages of steel in the longitudinals and in the spirals, as in this way alone the relative benefit of either kind of reinforcement can be obtained.

Mr. Withey sums up his conclusions in regard to such relative benefit as follows:

"It appears that the ultimate strength of this class of columns is raised more by increasing the strength of spiral than by increasing the percentage of longitudinal reinforcement. That this statement does not hold for the stress at yield point can be seen. . . . It will be observed that the stress at yield point is directly dependent upon the percentage of longitudinal reinforcement, but is not dependent upon the percentage of spiral reinforcement."

In other words: the spiral raises the point of ultimate destruction but has little effect up to the yield point. As long as it is immaterial up to the yield point whether we use $\frac{1}{8}$-in., $\frac{1}{4}$-in., or $\frac{3}{8}$-in. rounds for the wrapping, and this is plainly the meaning of Mr. Withey's last sentence, it is absurd to have the area or volume of the spirals included as a factor in the column formula.

More than this: from theoretical considerations Mr. Withey is convinced that spiral reinforcement, in amounts up to 2 per cent., does not materially raise the yield point, and he gives equations for unit stress of hooped columns at the yield point and ultimate respectively, which can be generalized as follows:

$$\frac{P}{A} = F + F_1 \quad (3)$$

$$\frac{P^1}{A} = F + F_1 + F_2 \quad (4)$$

The details of the formulas are omitted. What concerns us is the fact that formula (4) gives the unit stress at the ultimate and includes in F_2 the action of the coil, and that formula (3), which gives the unit stress at the yield point, omits any factor relating to the action of the coil.

Professor Talbot tells us that he feels "that there is yet much to be learned about concrete and reinforced concrete columns." This is very true, but with the properly designed hooped column a great stride forward has been made, provided we are not led astray by strange gods.

[NOTE.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by January 15, 1913, for publication in a subsequent number of the JOURNAL.]

SEWERAGE OF THE CITY OF PORTLAND.

By T. M. Hurlburt, Member Oregon Society of Engineers.

[Presented to the Society, October 10, 1912.]

Natural Conditions.

The original city of Portland, which includes nearly all of the business district on the West Side, is well situated for the prompt removal of all sewage. This area is distributed along the Willamette River, extending a few blocks back therefrom, and a comparatively short line of outfall sewer is needed to drain directly into the river. In fact, practically none of the present West Side offers any serious obstacles to the ready disposal of sewage. An area that may in time present some problems (when the city boundary shall be extended) in drainage is that beyond Council Crest, in the Tualatin Valley watershed, for which the Tualatin River is the only natural outlet.

It is only on the east side of the Willamette that we find territory within and also adjacent to the present city boundary that presents difficult problems in drainage, and it is only during the past few years that, on account of the great growth and expansion of Portland, these questions have come to the front. The great width of the area on the East Side, reaching to East 92d Street at the extreme eastern side, means much longer lines of sewers to reach the river than on the West Side. Besides this there are portions of the East Side that cannot be *directly* drained into the Willamette at all. Among these is a large area east of Woodstock, including all of the Mt. Scott district, and southeast of Mt. Tabor (reaching to a line running east from the summit of Mt. Tabor) that drains into Johnson Creek, for which a sewer running along Johnson Creek to its discharge into the Willamette in Milwaukee will be needed.

Another area is that with the Country Club grounds as a center, embracing about 750 acres, that has no outlet at all. A sewer to drain this district will cut through the low divide to the east of East 82d Street and then drop down to near the bottom of the deep basin that may be seen from the Oregon Railroad and Navigation Company trains, lying just southeast of Rocky

Butte, and then will require a long cut (with perhaps some tunnel) to cut out to the slope draining into the Columbia River, far beyond the present city limits.

The north part of the "Peninsula," lying between the Willamette and Columbia rivers, drains directly into the Columbia. The watershed line between the two rivers is the summit of the more or less prominent ridge that may be traced from near Rocky Butte, entirely across the Peninsula to the edge of the bluff at the west end of Killingsworth Avenue. This ridge is sharply defined on the southerly side by the comparative steepness of its slope, but on the northerly side it drops more gradually towards the Columbia. This district includes about 5 500 acres within the present city limits. The plans proposed for sewerage of this district will be mentioned further on.

Pioneer Sewer Systems.

The earliest record I find affecting sewers in Portland is an ordinance passed in 1864 authorizing the building of sewers in Montgomery Street. In 1865 we find an ordinance was passed authorizing the building of sewers in all of the east and west streets from Madison Street to Oak Street inclusive, and in November of the same year we find another ordinance appropriating $5 000 for sewers; both of these ordinances, I may remark, had to be passed over the mayor's veto. These sewers, so called, it appears from other records, were really wooden box culverts, for conveying the storm water under or across streets.

It is not until 1873 that we find a definite record of pipe sewers being laid, and in that year a line of terra-cotta pipe of 12-in. and 15-in. size was laid in Stark Street from 6th Street to the river. An expenditure of about $4 000 was made that year.

The original city of Portland, including nearly all the present business and most of the industrial part of town, is sewered by individual sewers running on each east and west street and discharging directly into the river. In reaching areas outside of this old section, districts have been formed with trunk sewer outlets.

Among the older trunk sewers are the Johnson Creek, Marquam Gulch, Tanner Creek, Thomas Street and Woods Street sewers, on the west side of the river, and the Holladay Avenue and East Alder Street (Sunnyside Sewer District) trunk sewers on the East Side. All of our older trunk sewers, including those completed as late as 1909, were of brick, and usually with an invert of either stone blocks or vitrified brick.

Of this old type of construction the last and the largest of the sewer systems built was the Brooklyn Sewer and its north and south branches, completed in 1909. These sewers are of brick with stone block inverts. The main sewer for 3 491 ft. has a diameter of 9 ft. 8 in. to 10 ft. and 1 646 ft. of it is in tunnel. The total cost of the main sewer and the two branches was $284 054. Further extensions of the two branches have been made, but these have been constructed of concrete.

Present Types of Sewer Construction.

Since 1909, all sewers of over 24-in. size have been built of either reinforced or plain concrete, or of reinforced concrete pipe sections. On grades with considerable velocity it is the practice to line the bottom quadrant with either stone blocks or vitrified brick, or in some cases with vitrified terra-cotta. For diameters up to 48 in. the use of pipe sections, which are made on the ground and afterwards lowered into the trench and connected, seems well adapted. A brief description will be given of the most important sewers under construction at the present time.

East Stark Street Trunk Sewers.

East Stark Street Trunk Sewer No. 1 extends from the Willamette River to East 21st Street and drains an area of 2 300 acres between East 33d Street and East 92d Street (at the city limits). East Stark Street is the most economical location for an outlet sewer for this district, although the sewer extends 8 600 ft. beyond the boundaries of the district in order to reach the river.

The grades for this sewer vary from 1.6 per cent. to 1.9 per cent., and, on account of high velocity of flow, a type of sewer with a flat invert was adopted in order to reduce abrasion. For invert lining basaltic stone blocks were used, as our experience has been that they give the most satisfactory service on steep grades. The calculated velocity of flow in this sewer is 18 ft. per sec.

In designing the sewer it was made large enough to carry a storm water run-off of 0.22 cu. ft. per sec. per acre, which is considered ample for the gravelly nature of the soil, and the moderate fall from the outer limits of the district. This sewer is 6 ft. by 5 ft. 11½ in. in size.

East Stark Street Trunk Sewer No. 2 extends from East Stark and East 21st streets to East Burnside Street and East

East Stark St. Sewer. Completed portion. Inspection trip.

Sullivan Gulch. Tunnel under Union Ave. and Grand Ave. before placing concrete.

Insley Ave. Sewer. Type of construction.

East 33d Street System. Lock Joint type of construction.

44th Street. This sewer is of the same type as No. 1 but is on a grade of only 0.5 per cent. Reinforced concrete is used in constructing the sewer, the invert being lined with vitrified brick. The sewer was designed to carry 500 cu. ft. per sec., which is the same capacity as No. 1. The sewer is 7 ft. 6 in. by 7 ft. 2 in. in size.

Sullivan Gulch Trunk Sewers.

Sullivan Gulch Trunk Sewer is being constructed under two separate contracts. The first section is from Willamette River to East 15th Street, the second from East 15th Street to East 33d Street.

The Sullivan Gulch Sewer drains a district having an area of 1 800 acres. The grades vary from 1 per cent. to 1.33 per cent. The sewer was designed to carry 0.23 cu. ft. per sec. per acre, or 415 cu. ft. per sec. Reinforced concrete is used in constructing the sewer except in tunnel, where plain concrete is used, stone blocks being used to line the invert. The calculated velocity of flow is 14 ft. per sec.

East 33d Street extension of Sullivan Gulch Sewer is the north branch of Sullivan Gulch Sewer. It drains an area of 600 acres. At the junction with the main sewer at East 33d Street, the sewer was designed to carry 0.33 cu. ft. per sec. per acre, or 200 cu. ft. per sec. Reinforced concrete pipe is used in construction, varying in size from 27 in. to 66 in. Where the calculated velocity of flow does not exceed 12 ft. per sec. no lining is used on the invert of the sewer, as the hard, dense material obtained in the manufacture of the pipe is capable of resisting the abrasion. The pipe is cast in 4-ft. lengths reinforced with wire mesh. They are kept moist for six days after the forms are removed, and they set hard enough in fourteen days to be lowered into the trench. The large sizes of pipe, say 42-in. and over, require a timber foundation to obtain a true grade line, as the weight of the pipe causes them to settle $\frac{1}{4}$ in. to $\frac{1}{2}$ in. when they are placed directly on the earth foundation. 66-in. reinforced pipe is being laid in the tunnel in East 33d Street. These pipes are cast in 4-ft. lengths and weigh 6 400 lb. They are lowered in the shaft by engine hoists and carried to their place in the tunnel by an overhead carriage running on an I-beam attached to the caps. A crew of men will, on an average in one day of nine hours, lay four lengths, grout the joints and thoroughly tamp the backfill. Enough of the tunnel excavation is left in place to be used in backfilling over the pipe.

Insley Avenue Trunk Sewer.

Insley Avenue Trunk Sewer drains 1 800 acres in the south-east portion of the city. The trunk sewer extends north from Lambert Avenue and follows approximately the course of Crystal Spring Creek to Insley Avenue, thence west on Insley Avenue to Willamette River. The flow in the trunk sewer will be in the opposite direction to natural drainage of country, so that a grade of 0.2 per cent. was necessary. On this portion of the trunk sewer a reinforced concrete section was used, the invert being lined with cement mortar plaster. The outlet toward the river is a 6-ft. circular sewer, the invert lined with stone blocks. The portion of this sewer in a tunnel of 1 200 ft. in length is of plain concrete, the remainder being reinforced concrete.

Canyon Road Sewer.

The Canyon Road Sewer extends from the end of Tanner Creek Sewer near the City Park to the city limits, a distance of 6 000 ft., and drains an area of 1 000 acres. The sewer is of reinforced concrete construction, the invert being lined with stone blocks. The grades vary from 4 per cent. to 14 per cent. In designing the sewer it was made large enough to carry a storm-water run-off of 0.5 cu. ft. per sec. per acre. This rate of run-off is 100 per cent. higher than that used for designing trunk sewers on the East Side. This is necessary on account of different soil conditions, and the nature of the topography. The sewer is horseshoe-shaped section, and is the equivalent of a 5-ft. diameter sewer at the lower end.

Proposed Sewers.

Reconstruction of Tanner Creek Sewer.

The Tanner Creek Sewer drains an area of 1 800 acres, including the area drained by Canyon Sewer at present under construction. It extends from the reservoir at the City Park to the Willamette River, a distance of 8 500 ft. The portion of the sewer from Washington Street to the river is in bad condition, due to poor construction and unsteady foundation. The sewer is also too small to carry the storm water during heavy rains, and it will be necessary to reconstruct at least the greater portion of the sewer. This will involve a relocation of the sewer entirely in the streets, and the construction of 7 000 ft. of new sewer, the largest being 9 ft. in diameter and the smallest 5 ft. in diameter. The old sewer will be refilled and placed in safe condition,

especially where it crosses private property. The total cost of the reconstruction will approximate $225 000.

Intercepting Sewer for West Side.

The discharge of the many sewers directly into the Willamette River harbor on the West Side, within the heart of the city, is befouling the water to an undesirable extent. The discharge end of most of these sewers is partly or entirely above low water. To remedy this it has been proposed to construct a main intercepting sewer for the entire length of the water front on the West Side through the settled district, to receive the discharge of the trunk sewers and other east and west sewers and conduct it to a point in the north end of the city before emptying into the river. This intercepting sewer would probably follow the streets nearest to the river, such as Front Street. Some study has been given to the design and cost of the sewer, but nothing definite has been decided on. It is probable that the plan finally adopted will be to extend the individual sewers well out towards the channel of the river, and secure a discharge below the water level at all stages. The minimum flow of the Willamette is such that it will properly dilute the sewage of a city with a population of between 500 000 and 600 000.

Proposed Columbia Sewer District.

As stated before, the northerly slope of the Peninsula drains towards the Columbia River. The collection of the sewage over all but the lower part of this slope and its discharge into the Willamette is possible, but this involves the construction of a large intercepting sewer on a necessarily light grade in order to convey the sewage around the northwesterly point of the Peninsula, beyond the city of St. Johns, where a turn to the left would finally reach the Willamette. This sewer would be very expensive, besides which the drainage of the land below it would require pumping to lift the sewage up to the level of the sewer.

On account of the wide expanse of bottom lands, subject to overflow, lying between the upland and the Columbia River, there would be required a long line of outfall sewer to reach the river. If only one outfall sewer be used, a long intercepting sewer at the foot of the slope would be required to receive the sewage from the various north and south sewers and convey it to the main outlet sewer.

The various plans for taking care of the sewage and storm water on the north slope of the Peninsula, possibly involving

the dredging out and use of Columbia Slough for a sewer outlet as well as for navigation, are matters that are likely to command considerable public attention and discussion before a definite plan of procedure is decided on.

The Columbia River Bottoms vary from one to two miles in width. They are, for the most part, overflowed during high water, and there are a number of shallow lakes and sloughs that contain water continually. The highest ground is that along the river bank. Along the southerly edge of the bottoms, near the foot of the main slope, is Columbia Slough, reaching from a point near Troutdale to the junction near the mouth of the Willamette. It forms a small bypass for the Columbia. This slough has a continuous flow though the current is very sluggish during the low water of the late summer and fall.

Columbia Slough is the natural discharge place for sewage and storm water originating on the northerly slope of the Peninsula, and from an economic standpoint alone it would be the only outlet considered. But it is open to the objection that the sewage would not be promptly carried away during low stages of water, and in time, with the settlement of the adjacent land, would become a positive nuisance. The possible plans for utilizing the slough for sewer purposes are as follows:

(1) The partial adoption of the separate system of sewage disposal for the district. A sewer or sewers of sufficient size to carry both sewage and storm water as far as the slough would be built. Reaching from the slough across the bottom lands to the Columbia River the sewer would be of size sufficient to carry the sewage proper and perhaps enough storm water to insure flushing it out, while there would be an automatic overflow in the combined sewer on the banks of the slough to spill the excess of storm water into the slough. Although at times this might carry some of the sewage wastes with it, it would be so diluted and the total quantity in any case would be so small that it should cause no appreciable nuisance.

(2) The slough's carrying capacity can be so increased by deepening and widening that the regular flow in it would suffice to carry off the total sewer discharge without any material harm resulting. This plan would also, incidentally, allow free use of the slough as a canal by small boats and barges.

(3) The construction of a channel of sufficient size for steamboats and ships, by straightening, widening and deepening the slough. This channel or canal would be perhaps 150 ft. in width, with wider places at intervals for turning around. With

this plan the securing of a navigable channel would be the chief aim, but the creation of a channel that would permit perfect disposal of the sewage would be such a large incidental that a part of the expense could be assessed against the sewer districts.

The inflow of water from the Columbia would probably be through an arm of the slough opposite a point between Clarnie and Fairview, which would be channeled out and be provided with regulating gates for proper admission of water from the river.

One of the obstacles, it may be stated, to construction of a complete sewer to reach the river is the crossing of this slough, as it is classed as a navigable channel, and a bridge crossing might in time, if the channel be afterwards improved, have to be replaced by an inverted siphon crossing which is decidedly objectionable for a sewer conduit.

The dredging of the boat and ship canal would provide material for filling in a considerable part of the adjacent lowlands. The greatest gain of all would be in providing several miles of waterfront on a navigable channel. The creation of a manufacturing or industrial district over what is now nearly worthless bottom lands, fit only for grazing, would seem to be assured.

[NOTE.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by January 15, 1913, for publication in a subsequent number of the JOURNAL.]

RAILROAD VALUATION: REPRODUCTION COST NEW AS A SOLE BASIS FOR RATES.

By D. F. Jurgensen, Member of the Civil Engineers' Society of St. Paul.

[Read before the Society, November 11, 1912.]

The ascertainment of the physical value of railway properties as an element to be considered in the establishment of rates has received the serious consideration of the Railroad and Warehouse Commission of Minnesota for many years past.

The Minnesota Rate Cases — Shepard *v.* Northern Pacific Ry. Co., and allied cases — resulted in a large volume of testimony bearing upon the subject, and the members of the Commission feel that their present views upon this question have been arrived at only after long and mature deliberation; and I am authorized to say the Commission indorses and supports the views herein expressed.

Before entering into a discussion of the correct method to be employed in valuing railroads, it will probably be well to quote the law bearing on the matter in hand.

In Smyth *v.* Ames, 169 U. S. 522, the following language is used:

"We hold, however, that the basis of all calculations as to the reasonableness of all rates to be charged by a corporation maintaining a highway under legislative sanction must be the fair value of the property being used by it for the convenience of the public. And in order to ascertain that value, the original cost of construction, the amount expended in permanent improvements, the amount and market value of its bonds and stock, the present as compared with the original cost of construction, the probable earning capacity of the property under particular rates prescribed by statute, and the sum required to meet operating expenses, are all matters for consideration, and are to be given such weight as may be just and right in each case.

"We do not say that there may not be other matters to be regarded in estimating the value of the property. What the company is entitled to ask is a fair return upon the value of that which it employs for the public convenience; on the other hand, what the public is entitled to demand is that no more be exacted from it for the use of a public highway than the services rendered by it are reasonably worth."

The law above stated is the best legal authority we have to direct us in our efforts in valuing railroad properties at the present time, but to maintain that it is an infallible guide that we engineers have but to follow to obtain correct results is, I believe, stretching the imagination.

If the law be read carefully, it is noted that there are laid down more than six questions or topics that are to be given such consideration and weight as may be just and right in each individual case in determining what is " fair value " of the properties. They are as follows:

1. Original cost of construction, plus amount expended in permanent improvements, which equals actual cost.

2. Amount of bonds and stock.

3. Market value of bonds and stock.

4. Present cost compared with original cost of construction.

5. Probable earning capacity of property under rates prescribed.

6. Sum required to meet operating expenses.

7. There may be other matters to be regarded in estimating value.

The law, then, in so far as the valuation is concerned, appears to be established, viz., that " the carrier is entitled to a reasonable return upon a fair value of the property being used by it for the public convenience." Also the fact that railroad properties used by the public for its convenience are public highways. Upon this latter point there is no discussion involved, but we are, however, confronted with the question: What is meant by the term " fair value " of the properties used by it (the carrier) for the convenience of the public?

It is essential when entering upon a discussion of so important a topic as the one herein involved that every aspect of the subject being discussed be understood and agreed upon in advance, and since valuation of railroad properties may properly be made for different purposes, the propriety of the method employed must depend upon the particular purpose for which it is to be made, and it is to be distinctly understood that this paper deals exclusively with valuation for rate-making purposes.

The government aims to secure two conditions in railroad rate-making, viz., equality and reasonableness. The question of equality need not again be referred to because it only enters into the problem when a division of values between different states arises; consequently the scope of this discussion is narrowed to valuation made for the purpose of securing reasonableness of

rates. This prompts us at once to inquire what is meant by the term "reasonable rate."

It is true that a rate may be so high as to be unreasonable without reference to the profit accruing to the carrier. It is only necessary here to consider what is meant by reasonable rate with reference to the cost of the service and a reasonable return to the carrier, so that when we speak of a reasonable rate or reasonable rates, as an entirety, we have in mind such rates as will allow for the cost of the service, depreciation of property, taxes and a fair return to the owner.

Nowhere in the decision above cited does it appear, nor is it even hinted at, that the fair value of the property being used by the carrier for the convenience of the public is the cost of reproduction new at the date of inquiry, as was adopted by the Master in Shepard *v.* Northern Pacific Ry. Co., but it does state, and very emphatically, that "the original cost of construction, plus amounts expended in permanent improvements," which sum equals the actual cost of the properties, is one of the primary matters to be considered.

The ascertainment of the present value of the physical properties becomes important upon the claim that the language above quoted, "the present as compared with the original cost of construction," indicates that another element to be considered is the present or reconstruction cost of the property.

Conceding, for the sake of this discussion, this to be true, I propose to demonstrate that the cost of reproduction new as adopted by the Master in Shepard *v.* Northern Pacific Ry. Co. has no basis in law or fact, and that if cost of reproduction is to be established as an element going to make up fair value, it in no event can go beyond showing the present actual value of the physical properties so devoted, and it is first necessary to determine what is tangible property that may properly be included in the inventory.

Franchises. — By franchise is meant "the right to transact business under the corporate form; to exercise the right of eminent domain; and to perform the public function of maintaining a highway." A mere statement of this element which in itself may be of incalculable value shows it cannot possibly be included, because to allow its inclusion results in the following absurdity:

A group of individuals requests authority from the state to organize themselves into a corporation, and in that capacity exercise the governmental function of eminent domain. Having

obtained this authority as a free gift from the state, it is proposed to tax the public on that account; in other words, to collect rates from the public which will yield a return not only upon the tangible properties devoted to the service, but upon the intangible consent of the state that the tangible property might be so employed.

Good-Will. — This is another name for opporunity. Opportunity is created by a multitude of conditions, and it may justly be said in this instance that "the carrier has contributed its proportion" just as each individual has and does contribute his share, and if opportunity or good-will can properly be included as an element of tangible value, it will be impossible to ever establish a governmental limit for rates.

Going Concern. — What has been said with reference to good-will applies with equal emphasis to going concern; therefore it must also be excluded as an element of tangible value.

Properties to be Included. — When, therefore, it is proposed to ascertain the present value of the tangible properties of a railway company as an element in arriving at an amount upon which to compute return, the physical valuation should give only the actual present value of the physical properties in existence at the time of inquiry and used for transportation purposes, so that in discussing the propriety of the so-called "reproduction method," its soundness is to be determined by considering whether or not it leads to the above conclusions as to actual present value of specific items of tangible property.

Reproduction Method. — It is apparent, therefore, that the reproduction method may or may not lead to correct results. When the appraiser confines his investigations to facts and actualities, no fault can be found with the method for purpose of arriving at present value, but if followed as proposed, and the assumption of reconstruction itself is taken as an element of additional value, the conclusion is arrived at by imagining conditions which do exist to be non-existent, and those which are non-existent to be actualities. The result of such interpretation is that the base upon which the return is to be computed is not actually in existence, but is a mere fiction established on purely imaginary and impossible assumptions.

The payment of rates by shippers and consumers is a stern actuality and necessity, and if it is just and proper to predicate rates upon a fanciful or imaginary condition, why should not the consumer also be privileged to indulge in dreams and base his payments upon imaginary conditions favorable to him?

Erroneous Method Adopted in Shepard Case. — In Shepard *v.* Northern Pacific Ry. Co., the Circuit Court held that the carrier was entitled to a return upon the cost of reproducing new.

The method adopted by the Master in that case for arriving at cost of reproduction new illustrates, I believe, in a most striking manner, the startling results which must follow if the reproduction method is to be solely relied upon for ascertaining fair value, and because of this I have determined to use the findings in that case as my basis for this discussion. That the method so adopted led to imaginary and false conclusions can best be shown by dealing separately with the items of the so-called inventory.

Formula. — The formula adopted as a preliminary may be briefly stated as follows:

The railway was presumed to be non-existent; that it was necessary for the company to presently acquire each item of property used in the service, and an inventory of the property was made which may, for convenience, be divided into two classes:

(*a*) Land exclusive of improvements.

(*b*) All other properties, including improvements upon land, equipment, bridges, tunnels, etc., under the title "Construction."

Land. — Whether or not lands donated for right-of-way purposes should be included in the inventory, or whether or not easements secured by the exercise of the right of eminent domain should, in any event, be included at a larger amount than the original cost of acquisition, are questions which do not properly belong to this discussion, and, in the interest of simplification, these questions will herein be ignored and we will assume that an inventory of the exact acreage of all lands held and used exclusively for railroad purposes be prepared. We are then confronted with the problem of ascertaining the present market value of the land.

By the reproduction method as applied in the Shepard case, no attempt was made to ascertain the present market value of the lands, but instead it was undertaken to find what it would cost the company to purchase these lands at the time of inquiry, on the assumption that the lands were not at the time owned by the company and upon the claims that because of the necessity of securing continuous tracts of land for railroad purposes, damage done to abutting property by the construction of a railroad, increase in value accruing to lands from the prospective

construction of a new line of railroad, and excessive awards allowed by commissioners and jurors, railroad companies habitually paid from three to five times the market value of land; therefore, if the problem was to ascertain the cost of reproduction, the amounts so found would necessarily be in excess of the actual market value.

The Master said:

> . . . "that is, the market value of adjacent lands has been determined and applied to the right-of-way lands, at such values, multiplied by three to ascertain what it would cost a railway to acquire the property."

The method adopted by the Master, therefore, is based upon the false assumption that the company is under the present necessity of purchasing the identical lands to be valued. The problem in hand is in fact the ascertainment of the present real value, which is necessarily the present market value. The Master, however, finds that by adopting the reproduction method, the proper procedure is, after having found the present actual or real value, to increase it by some multiple, the multiple adopted by him being $2\frac{1}{4}$.

If a railroad company is entitled to earn a return upon the real value of its property, and if such real value is to be taken as of the present time, it shares in the general prosperity of the country and gets the benefit of any advance in land values. If, on the other hand, it could be shown that the actual and necessary cost of any tract of land used by a railway company, because of the peculiar conditions surrounding its acquisition, exceeded its actual market value, there would be some substantiality in the claim that the company should be allowed to inventory it at its actual cost.

If the actual cost of a tract of land purchased many years ago was the problem, it might be fair to assume that the actual cost was more than the then market value, but in cases where there is absolutely no question but that the present real market value exceeds many times the actual original cost, there is no possible logical basis for the claim that the land should now be taken, not at its real value, but at some imaginary sum which it is held might necessarily be paid if the company were now compelled to purchase that identical tract.

The method is so weird and fantastic a procedure that it is difficult to make more than a mere statement of the proposition itself. In this instance, there seems to be no necessity for

the use of *reductio ad absurdum*. The statement of the claim involves this of itself.

The Supreme Court of the United States has laid down the test for determining value of lands in condemnation proceedings, in

Miss. & Rum River Boom Co. *v.* Patterson, 98 U. S. 403.

The Court said, page 407:

. . . . "in determining the value of land appropriated for public purposes, the same considerations are to be regarded as in the sale of property between private parties."

Therefore, a railroad company, in taking land from a private party to-day, is only required to pay him the market value of the land as it would be determined in sales between private parties, according to the Master; to-morrow, when that same tract is inventoried for the purpose of determining a return to the railroad company, for its use, it is to be taken at 2½ times its real value.

Rights in Streets. — In each of the large municipalities through which railroads pass, some traffic privileges have been granted upon public streets. Very often these privileges are obtained by the companies without money consideration. Occasionally, some small amounts are required to be paid to satisfy damages accruing to abutting properties; however, in either case, the land so occupied by the tracks is not owned by the railroad company, — it has the privilege of using the highway just as have street railway companies. In the Shepard case, the areas so occupied were included in the inventory of the lands, and at the same value; if this method of procedure be correct, it will apply with equal force where a valuation was to be made of the properties of a street railway company, in which case we would proceed as follows:

(*a*) The area of the principal streets of the municipality will be computed.

(*b*) The present market value of the land ascertained, this amount would then be multiplied by some factor dependent upon the individual judgment of the examiner, and the result so obtained is then to be taken as the basis upon which to compute a fair return.

Items of Construction. — The problem having thus been shifted from ascertaining present value to the cost of reproducing the railway new, no allowance was made for depreciation. This

was directly contrary to the holding of the Supreme Court in the Knoxville Water case. It scarcely seems necessary to quote any authority to establish the fact that depreciation cannot be ignored if the fact to be found is " present value."

Whether or not such items as cash on hand, adaptability and solidification of roadbed, etc., are to be included, is a legal question and does not properly belong in this discussion. The question here involved is entirely within the science of mathematics in that the result must be based upon actual physical facts; that certain items of property depreciate in value from wear, use and action of the elements is a fact; the amount of such depreciation must be found as a pre-requisite to finding or determining " present value."

Overhead Bridges. — In one of the cases allied with the Shepard case, allowance was made for overhead bridges spanning the right-of-way of the company. These bridges had been constructed and paid for by the municipality. This allowance was made solely upon the false assumption that a reconstruction of the railway was necessary, in which case the company would be compelled to pay the cost of constructing these overhead bridges.

This particular item had not been contributed by the company. The company had devoted no such property to the service. Its inclusion resulted in allowing a return upon the property of some one else and again we reach a position so absurd that intelligent argument is impossible.

Unit Prices. — The false assumption as to the necessity of reconstruction and the acquisition of the identical items of property making up the inventory leads to another absurdity, viz., that the immediate or forced construction of great railroad systems tends to stimulate or enhance prices, and that in some instances, such as in the replacement of oak ties, etc., the present supply being limited, it will be necessary to seek and purchase these articles in distant and foreign markets at fabulous prices.

If railroad properties have a sentimental value; if rails, ties, switches, etc., are to be classified with old china, antique furniture and first editions, it may be proper to ascertain the values in this manner, but if the problem is to ascertain what it would cost to construct a proper roadbed with efficient rails and ties, the method adopted did not establish present value, but added " sentimental value."

Imaginary Items. — Having found a false and excessive value for the items inventoried, allowances were added for

interest during construction, contingencies and engineering. These items are purely imaginary, and, being illusive, their measure depends upon the ability of the appraiser to imagine. This is well illustrated by the history of the item.

Interest during Construction. — In order to arrive at this amount, the appraiser first determined in his own mind the period during which this imaginary construction was to continue, so that it becomes apparent that if we conceive a road to be constructed in one day, but one day's interest will be incurred. If the construction occupies a century, the interest charges will be very heavy. The appraiser to justify this item must, of course, carefully ignore the fact that during this imaginary construction period, the road is in actual existence and bringing in a substantial return. This item therefore, affords to the appraiser as great opportunities for ignoring actual conditions as for assuming conditions which do not and cannot exist.

In giving the reproduction cost of the Northern Pacific Ry. Co., in the Spokane rate case, decided February 9, 1909, it was claimed on behalf of the company there should be allowed for interest during construction, $23 000 000. In the Shepard case, the same witness gave a value as of April 30, 1908, in which he estimated the interest item at $39 804 659, while in the case of the Interstate Commerce Commission *v.* Union Pacific Ry., known as the Lumber Case, it appears on page 116, Vol. 1, of the record in that case that the amount claimed for interest during construction of the Northern Pacific Railway as of April 14, 1909, was $164 000 000.

The mileage of the road at the times for which these estimates were made was practically the same, as was also the equipment. These estimates were all made by the same witness, a gentleman of high character and undoubted ability, yet something more than twenty-two per cent. of the entire value so claimed was made up of this purely fictitious and imaginary item called "interest during construction." It was inserted in the inventory because the witness was at liberty to assume any period for construction which suited the exigencies of the case. Contingencies, superintendence, legal expenses, engineering and other items of like character are equally as fictitious and illusive as the item *interest* just discussed.

Importance of Physical Valuation. — Engineers, when called upon as experts to furnish information to the judicial tribunals, should base their deductions upon facts and not upon false, dangerously fictitious and imaginary assumptions. Whenever

the expert witness ignores actual facts and indulges in wild dreams and assumptions, his testimony becomes utterly worthless and unreliable. The value of any testimony depends primarily upon the facts and true conditions surrounding the issue involved.

The reproduction method for arriving at present value as now advocated by the railway companies of the United States is based primarily upon the false assumption that it is necessary now to acquire and construct the railroad properties. In carrying this idea out into the minor details that are involved, new assumptions, equally as false and fictitious, are met at every step of the proceeding, with the result that the final conclusion is as far removed from the actual "present value" as the assumption, — for the necessity of reconstruction is removed from the fact of "present existence"; and it is demonstrable that the cost of reproduction new by the methods so advocated and adopted in the Shepard case is not a correct or proper course by which to ascertain "present value," much less does it furnish a sole basis for a return.

The engineers of this country that are connected with governmental and state officials, charged with the supervision of railroads and railroad rates, occupy a most important position. It is of vital importance that they confine themselves to actualities, to the end that the valuations which will of necessity have to be made in the near future be made upon sound principles based upon fact.

For example, a locomotive is to be valued; the price of a similar locomotive on the market to-day is known; the average life of a locomotive is known; its present physical condition is apparent. Its present value compared with the present price of a similar new one presents a simple problem, and when the engineer has stated these results, his duty is at an end, and so on through each item of the inventory.

The engineer by thus confining himself to actual facts will present an estimate based upon fact, which is proof in itself. By such methods, not only will the members of the profession protect themselves from adverse criticism, but they will also have the satisfaction of contributing something toward preserving lucid thought and something toward the simplification of what is perhaps the greatest problem before the American people to-day, viz., the establishment of a correct and logical basis for valuing and appraising the properties of the public service corporations.

It is seldom found that masters in chancery or judges of courts are profound mathematicians; therefore, it is extremely desirable that the mathematical questions involved in rate cases be presented to the courts in the most simple form possible. So I say, let us confine ourselves to statements of fact, and, with the facts before them, let the courts declare the law and determine what items or elements of value should be included in the fair value upon which a return to the carrier is to be based. This amount should be what the Supreme Court of the United States has so far somewhat indefinitely designated as "fair value of the property devoted to the service."

It seems unthinkable that "fair value" can be more than present value of items of physical property rightfully included in the inventory. The attempt to substitute "cost of reproduction new" by the methods hereinabove outlined is in truth an attempt under the title of physical valuation to establish an amount which would be more than sufficient to absorb unearned increment, watered securities, depreciation, good-will, going concern and franchises of every description, and thus under a new name and garb put back into the valuation all of these elements which, under the decisions of the courts and the consensus of opinion, must be excluded.

I desire to acknowledge my obligation to Hon. Thos. D. O'Brien, of St. Paul, for valuable aid and assistance rendered in the preparation of this paper.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by January 15, 1913, for publication in a subsequent number of the JOURNAL.]

ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XLIX. JULY, 1912. NO. 1.

PROCEEDINGS.

Boston Society of Civil Engineers.

BOSTON, MASS., APRIL 17, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.45 o'clock, President James W. Rollins in the chair; eighty-four members and visitors present.

The record of the annual meeting held March 20, 1912, was read and approved.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named: Members, Herbert Neal Cheney, Gordon Hildreth Fernald and Benjamin Greely Fogg, and as an Associate, George Taylor. He also reported that the Board had elected Frederic I. Winslow, librarian, and had appointed, under authority of a vote of the Society passed at the annual meeting, the following committees:

On the Library: F. I. Winslow, G. V. White, H. T. Stiff, H. D. Woods and W. E. Foss.

On Excursions: C. R. Gow, L. E. Moore, J. B. Flaws, W. O. Wellington and E. M. Blake.

On Code of Ethics: C. T. Main, F. P. Stearns, G. B. Francis, C. R. Gow and C. B. Breed.

On Publications and to Represent the Society on the Board of Managers, Association of Engineering Societies: S. E. Tinkham, Dexter Brackett, C. W. Sherman, G. A. Kimball, H. P. Eddy, A. T. Safford, J. R. Worcester and H. F. Bryant.

On motion of Mr. E. W. Howe, the thanks of the Society were voted to the Stone & Webster Engineering Corporation for courtesies extended to members of the Society on the occasion of the visit this afternoon to the work now under construction by that corporation for the Edison Electric Illuminating Company, on Massachusetts Avenue, Dorchester.

The Secretary then read the following report:

BOSTON, April 15, 1912.

To the Members of the Boston Society of Civil Engineers:

The Engineers Club has voted to exercise the option of leasing the property at No. 2 Commonwealth Avenue, and are pushing to completion the plans for remodeling the same, so that it will be suitable for the club and for a home for the Boston Society of Civil Engineers.

The club is now an assured success, as the number of resident members is over 400 and the non-resident about 100, and the remaining number to make up the full membership can easily be obtained. The membership is comprised of men whose standing in the community assures the success of the club on a high standard and will cause the club to be of great influence in affairs.

This club will meet a long-felt need for better social relations between engineers and others engaged in scientific pursuits and in business which is related to engineering. It will be a good beginning toward the combination of all the different branches of engineering, and such a combination should tend to strengthen the standing of the profession in this community.

The club proper will contain all the usual appointments for a modern, first-class club, including dining rooms for both ladies and gentlemen, reading room, sleeping rooms, billiard rooms, bar, etc.

It is expected that the building will be ready for occupancy about the last of this year.

The Boston Society of Civil Engineers has for several years been accumulating a Permanent Fund with the hope of some time getting established in a home of its own. At the rate of accumulation it would be many years before the Society could own and maintain a house suitable for its needs and worthy of the Society.

The present quarters of the Boston Society of Civil Engineers have become inadequate, and new and more suitable quarters must soon be obtained. The Society is now a tenant-at-will and can move on giving six months' notice.

The Society has before considered the purchase of property for a home, and out of the deliberations on this subject grew the idea of an Engineers Club, with a home for the various engineering societies. This movement has been given the moral support by vote of the Society and by action of the Board of Government at various times, and all recent plans for the Engineers Club have been based on the assumption that the Society would take quarters in the club house.

From the record of the meeting of June 15, 1910, is found the following, which relates to the original plan of having an Engineers Club on a very large scale.

"The President stated that, in answer to a communication from the Joint Committee on Club-House and Society Headquarters, the Board of Government recommended the passage of the following votes:

"1. *Voted:* That the Society approves the general scheme for the proposed Society Headquarters and Engineers Club, as outlined by the Joint Committee in its circular dated June 6, 1910.

"2. *Voted:* That the Society desires quarters in such a building as is proposed, and is prepared to pay a total annual rental not exceeding $2 500 therefor, in addition to salaries of independent or joint officials.

"3. *Voted:* That the Society advocates the joint maintenance and use of its library with those of other societies, but desires, as far as practicable, to preserve an independent ownership of books and periodicals.

"Also that the Society desires the joint use of social rooms for all its members, but is unable to offer any additional rental above the amount specified in the second vote.

"4. *Voted:* That it is the opinion of the Society that its members individually or collectively will actively interest themselves in securing tenants for any headquarters building of approved design and location.

"After amending vote 2 by striking out the amount of rental named and leaving the amount to be inserted to be determined by the Board of Government, the several votes were passed, on motion duly made and seconded for each vote."

The provisions for the Society, which have been made in the plans under preparation, are an assembly hall on the ground floor, capable of seating comfortably about 225, with a maximum capacity of 250. There is also on this floor, for use in connection with the assembly rooms, a coat room and toilet room. On the next floor above is the stack room for books, and just above this a library or reading room, with a small room for a clerk or stenographer. There will be shelf room enough in the stack room and library to hold all of the books now in the library of the Boston Society, and space in the

assembly hall for shelves for a large number of books which may be added in the future. Books used very seldom could be placed here. An entrance on Arlington Street will be made for the Society, and there will be a direct connection with the club quarters. The club will furnish heat and janitor service for the Society's quarters.

The club proposes to grant to the Society the use of the assembly hall, reserving it for such meetings of the club and other engineering societies as do not conflict with the regular use by the Boston Society of Civil Engineers. It will thus be seen that the Society will have almost the entire use of this room. The Society will have exclusive use of the library, stack room and small office. It is the intention of the Board of Government of the Engineers Club to have the assembly hall used generously for meetings of all engineering societies, with a view of making the club a center for engineering activities.

The members of the Society who are not members of the club will have the privileges of the dining rooms extended to them on the evenings of the regular meetings of the Society and on the day of the annual meeting.

In order to make suitable provisions for the Boston Society, as described above, it is necessary for the club to expend a large sum in excess of what otherwise they would be obliged to for a club alone, and for this expenditure it must pay the fixed charges. Added to this is rental for the portion of the land under the quarters of the Society and that portion of the floor space in the present building occupied by the Society. It has been carefully estimated that the annual cost of these charges and maintenance of the space required by the Society will be something more than $2 500 for the Engineers Club, and that a fair rental to be paid by the Society is about $2 500. This rental is considerably in excess of that now paid by the Society, but in return for the excess the Society will be housed in a building used exclusively for engineering purposes and will be at the center of engineering activities. It will be established in a more permanent and commodious home and one which will be more attractive than its present quarters. It will join itself to a movement for increasing the importance of the profession.

In all probability new quarters in any locality or an increase in floor space at the present location will mean an increase in rental, and this should be considered rather than the present rental in making comparisons.

As said before, the Society has been accumulating a fund for a permanent home. It is, therefore, proper that the income of the Permanent Fund, or a portion of the same, should be used to maintain a permanent home, and the increase in rental can be met in this way.

By the financial arrangement, as planned by the club, no funds of the Society need be invested in the property and the Society is, therefore, relieved of any chance it might take on an investment for a building of its own, the only obligation being that of rent, which can easily be met. If this enterprise is as successful as it should be, in all probability more property can be purchased in the future and arrangements made for accommodating all the engineering societies in Boston.

This undertaking should not be considered on a financial basis only. There is a good deal of sentiment connected with it. It is the most important movement which the engineers in this vicinity have made in recent years. The center of all engineering interests should be the Boston Society of Civil Engineers. It is the oldest society and the strongest society, outside of the national societies, and should gather about itself, not only civil engineers but engineers of all the different branches; and it may not be far distant when the suggestion of one of our recent presidents will come true, that we shall become the Boston Society of Engineers.

It is hoped that the Society will not allow this opportunity — to identify itself with this movement — to go by without embracing it.

The Board recommends the passage of the following vote:

Voted: That the Board of Government be authorized to lease quarters from the Engineers Club, to include stack room, library, office and auditorium, and to pay therefor not exceeding $2 500 per year, under such terms of use and occupancy as may be acceptable to the Board.

For the Board of Government,

JAMES W. ROLLINS, *President.*

Mr. Main moved that the recommendation of the Board be adopted, and the motion was duly seconded. The architect who had prepared the plans for the Engineers Club explained, with the aid of lantern slides, the proposed arrangement of rooms in the club house with particular reference to the quarters to be leased to the Society.

A very full and free discussion followed in relation to the proposed quarters and the desirability of making the change. An amendment was then offered to the motion to adopt the recommendation of the Board, that the matter be submitted to a letter ballot, which was duly seconded. On a vote being taken, the amendment was adopted, thirty-eight voting in favor and eighteen against. It was then voted that the recommendation of the Board of Government in its report be submitted to the members of the Society for a letter ballot.

A discussion then took place as to the advisability of sending out, with the letter ballot, a circular giving the arguments in favor of and against the recommendation of the Board, and after various motions had been suggested, it was finally *voted:* That a committee of six be appointed by the chair, three in favor and three against, to prepare arguments to be submitted in a circular to accompany the letter ballot.

The President appointed the following past presidents of the Society as members of the committee: Messrs. Frederic P. Stearns, C. Frank Allen, George A. Kimball, Joseph R. Worcester, Henry F. Bryant and Charles T. Main. See report of this committee as printed on page 5.

The President expressed his regrets that the hour was so late that it would be necessary to postpone to a later date the presentation of the interesting paper which Mr. Dean had prepared for this meeting.

Adjourned. S. E. TINKHAM, *Secretary.*

BOSTON, MAY 10, 1912. — A special meeting of the Boston Society of Civil Engineers was held at the Boston City Club this evening at 8 o'clock.

The students taking the civil engineering course at Harvard University, at Tufts College and at the Massachusetts Institute of Technology had received special invitations to be present at this meeting, and nearly 200 accepted. The total attendance of members and guests was about 275.

Mr. James W. Rollins, President of the Society, in a brief address extended a cordial welcome to the students, after which Mr. Leonard Metcalf, with the aid of lantern slides, gave a very interesting talk on "Some Recent Developments in Sewage Purification Methods."

At the close of the talk, light refreshments were served and a social hour was enjoyed, enlivened by singing and other entertainments on the part of the students.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., MAY 15, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.45 o'clock, President James W. Rollins in the chair; sixty-five members and visitors present.

The reading of the record of the last meeting was dispensed with and the record as printed in the May *Bulletin* was approved.

The Secretary reported for the Board of Government that it had elected

Messrs. Walter Nathan Charles, S. John Connolly, Arthur J. W. Harty, Franklin L. Mason, Ira Welch McConnell and Herbert A. Moody, members of the Society.

The President announced that the Society would tender an informal reception to the foreign engineers visiting Boston the first week in June at the close of the Twelfth International Congress of Navigation. The reception would probably be held in the City Club on Thursday, June 6, 1912.

On motion of Professor Allen it was voted that the Board of Government be authorized to fix the time and place for holding the regular meeting in June other than as provided in the by-laws, if they deem it desirable.

On motion of Mr. Fay it was voted that the Boston Society of Civil Engineers extend a most cordial invitation to the American Society of Civil Engineers to hold its annual convention for 1913 in the city of Boston.

Messrs. F. H. Fay and C. M. Spofford, the tellers appointed to count the ballots upon the adoption of the recommendation of the Board of Government authorizing the Board to lease quarters from the Engineers Club, reported as follows:

Total number of ballots cast, 314; Yes, 110; No, 203, and one unsigned. In accordance with this report, the President declared that the recommendation was not adopted.

On motion of Mr. Main, it was voted that the Board of Government be authorized to extend the lease for Society quarters in Tremont Temple and to acquire such additional quarters as in the judgment of the Board are necessary.

Mr. Arthur W. Dean was then introduced and read the paper of the evening entitled, "The Construction and Maintenance of State Roads in Massachusetts."

Mr. Hugh L. Cooper, chief engineer of the Hydraulic Construction Company, was then introduced and with the aid of lantern slides gave a most interesting account of the Keokuk Water Development.

After passing a vote of thanks to Mr. Cooper, the Society adjourned.

S. E. Tinkham, *Secretary.*

Report of Special Committee on Leasing Quarters from Engineers Club.

APPOINTMENT OF COMMITTEE.

By a vote of the Society passed Wednesday evening, April 17, a committee of six was appointed to prepare arguments for and against the leasing of quarters for the Boston Society of Civil Engineers in the Engineers Club, the membership to be equally divided between those who had favored and opposed such action.

The committee agrees on the following facts.

SPACE IN PRESENT QUARTERS.

Large room on seventh floor	700 sq. ft. area	11.3 ft. high
Small room on seventh floor	215 sq. ft. area	11.3 ft. high
Corridor room on seventh floor	350 sq. ft. area	8.15 ft. high
Total	1 265 sq. ft. area	
Chipman Hall, sixth floor	2 580[1] sq. ft. area	21.9 ft. high
Total	3 845[1] sq. ft. area	

[1] Not counting the gallery of Chipman Hall.

SPACE IN PROPOSED QUARTERS.

Society room on second floor.........	466[1] sq. ft. area	9.5 ft. high
Stack room on third floor............	466[1] sq. ft. area	12.5 ft. high
Total except assembly room......	932[1] sq. ft. area	
Assembly room in basement.........	1 235 sq. ft. area	16.0[2] ft. high
Galleries..........................	379 sq. ft. area	
Coat room and toilet room..........	144 sq. ft. area	
Total.........................	2 690[1] sq. ft. area	

SHELF ROOM.

At present we have 1 300 sq. ft. of wall area for book shelves. The librarian states that 1 800 sq. ft. is needed for our present library.

In the proposed quarters there will be:

In stack room........................	1 980 sq. ft. wall area for shelves.
In society room......................	400 sq. ft. wall area for shelves.
Total...........................	2 380 sq. ft. wall area for shelves.

This would provide space for about 32 per cent. more books than we now have. Equivalent book capacity can be had in the present quarters by utilizing the small room and corridor for stacks.

FIRE RISK.

Our present quarters are in what is called a "first class" building, surrounded on three sides by buildings of second class construction.

The Engineers Club will be in a "second class" building which will be made "first class" in the rear part devoted to the Society. The separation will be by a fire wall, which will be penetrated by doorways on each floor.

RENTALS.

The rooms leased by the Society at Tremont Temple cost $1 800 per year, but the Society receives from its tenants, the Hersey Manufacturing Company, $500; the New England Water Works Association, $400; and the Gas Engineers, $100; so that the net cost is $800. In addition, Chipman Hall is paid for when occupied. During the past year, it cost $120, making the total cost to the Society, $920.

The rental of the proposed quarters will not exceed $2 500. This possibly may be reduced by sub-leasing.

ARGUMENTS.

The following are the arguments prepared by the committee for and against leasing quarters for the Society in the Engineers Club.

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[1] Sixty-six sq. ft. on the second and 66 sq. ft. on the third are contingent upon the addition of a bay window which it is expected will be built.

[2] It is not possible to make a definite statement with regard to the ventilation of the new assembly hall, but it is expected that adequate methods will be adopted.

LOCATION.

Argument for Change.

The location and a brief description of the property are given in the report of the Board of Government.

For an up-town club, the location is unexcelled, with its beautiful outlook upon the Public Garden, its easy walking distance from all important points, and its proximity to the electric cars.

For general meetings of the Society it is convenient, quiet and accessible. At present it may seem a little inconvenient for use of the library, but business and the growth of the city are moving in that direction, and the business center is gradually coming nearer. This movement will be accelerated by the development of the Park Square district and the Arlington Street extension.

Argument against Change.

The present location is nearer most of the important lines of passenger traffic, including the Tremont Street, Cambridge and Washington Street subways, and the South and North stations. It is also much nearer a very large proportion of the engineering offices of the members and is therefore a much more convenient place for the library, for the Secretary and Librarian and other officers of the Society, for committee and Board of Government meetings and as a place for engineers to meet their friends or clients by appointment.

ADEQUACY OF ACCOMMODATIONS.

Argument for Change.

The library, stack room and office are not as large as the present quarters, but the efficiency of the space is much greater. The present quarters are not well arranged for the library. The stack room and book shelves in the new quarters will have about 50 per cent. greater capacity than the present ones. The reading room will be ample for such uses to which it is put. The use of the assembly room for nearly all the time and for various purposes should more than offset the smaller area of the other rooms, and in comparing the figures given above, it should be remembered that Chipman Hall is available only for meetings, while the new auditorium is available for books, officers' desks and general purposes at any time when not in use for meetings and, therefore, makes the new quarters larger than the present.

The assembly room is large enough for all meetings except those of unusual interest, and these can be held, as now, in some larger hall. It is thought that such a room will be more enjoyable for ordinary use than a larger one.

Argument against Change.

For the purposes of the general meetings, the proposed assembly room will be far inferior to Chipman Hall. It will have only half the area and less than two-fifths the air space. A large meeting will require the occupancy of the seats in and under the galleries, which are undesirable locations when discussions are in progress.

The present quarters, other than the assembly room, include three rooms used by the Society on one floor, with a total floor space of 1 265 sq. ft., while the corresponding rooms in the proposed location consist of two rooms on two

floors, with a floor space within the present limits of the house of 800 sq. ft., which can probably be increased by a bay window to 932 sq. ft., but if a private stairway from one floor to the next is provided, the floor space on both floors will be diminished by the area occupied by the stairway.

The present quarters can be increased by the addition of an adjoining corner room 18.5 ft. square on the front of the building at a cost of $500 a year provided the Society will take a lease for a term of years, or it can obtain one or more rooms, lighted by a skylight, in the rear of the corridor included in the present quarters, which would provide convenient space for book stacks and an additional well-lighted reading room. At the club house there will be no opportunity for further development, unless additional property is acquired.

As nearly all of the upper room at the proposed quarters would be devoted to book stacks, the room below, having an area not exceeding 466 sq. ft., must contain substantially all the tables, desks, revolving bookcase, telephone booth, pamphlet and map cases and other furniture required by the Society, such as are now located mainly in two rooms having together twice as much area. Such a room would be too crowded for comfort.

Were it desirable for the Society to adopt such cramped quarters for its principal room, as it must necessarily adopt in the proposed location, it could devote a large part of its present quarters to book stacks and so provide for the growth of the library for a long time in the future; but expansion and not contraction should be the policy of the Society.

It may be suggested that taking a part of the present main room for book stacks would prevent its use for informal meetings, which in the case of the proposed quarters could be held in the assembly room, but this objection is not serious because during the last year there were no informal meetings, and if they were to be held, satisfactory accommodations could be obtained on the same floor in the social hall at a cost of $5.00 per meeting.

The provision made for the use of the proposed assembly room by the Society, at times when it is not in use for other purposes, does not add materially to the adequacy of the quarters for general use by the members of the Society, as a large room partly below ground containing seats would not be attractive for such use.

COST.

Argument for Change.

The cost will necessarily be more for rental than at present, but the amount now paid will soon be increased on the acquisition of larger quarters. The use of a portion of the income of the Permanent Fund would seem proper, as the Society is by this arrangement provided with a more permanent home without any expenditure of its capital. The increase can thus be met without adding any burden to the members. If the Water Works Association and New England Gas Association go with the Society, the net rental would be reduced to about $2 000.

The cost to the club of maintaining quarters for the Society will be more than the maximum rental which it expects to receive.

A long lease by the Society is not required. If it is not satisfied with the results, or it finds itself in a position to acquire other property, it can move with no loss except for extra rental and expense of moving.

Argument against Change.

The rental cost of the proposed quarters will be $2 500 a year, with no assured reduction from sub-letting. This annual expense is to be compared with $920 per year for the present quarters, which are much more commodious. The cost of moving the library, altering some of the present bookcases and procuring new book stacks will be a considerable sum. There is likely also to be considerable additional yearly cost for the attendance and clerical services required at the proposed quarters, because the cost for these purposes in the past has been materially diminished by the coöperation of the tenants of the Society. The Society can expand its present quarters to a large extent without reaching the cost of the smaller quarters in the proposed location.

PERMANENT HOME FOR THE SOCIETY.

Argument for Change.

The Society has for two years been seriously considering the acquisition of a permanent home. Considering the Society alone, it is not likely to accomplish this for many years. After more than two years of work a plan has now been worked out which is financially possible, for the Engineers Club to proceed and to provide permanent quarters for the Society, the club to furnish the social features and to be the financial backers.

It is a modest beginning. The Society should not expect the most luxurious or capacious quarters, but it is expected that it will not be long before other property will be acquired which will then enable the Society to increase its floor space if it so desired.

Argument against Change.

A permanent home for the Society should be a well-located building of moderate size, controlled by the Society, with its name on the front door, or adequate quarters in a large building.

The present proposition to provide two moderate sized rooms across the back of a building formerly used as a dwelling, and the joint use of an assembly room at the rear of the property, extending about seven feet below the sidewalk level, both entered from a side door on Arlington Street, does not fill the above requirements for a permanent home.

The leasing of the proposed inadequate quarters would, on the other hand, tend to defer the acquisition of a permanent home by the Society, as it would according to present plans require a part of the income of the Permanent Fund to pay the rent.

The Permanent Fund now amounts to $30 000; it has increased $10 000 in the last five years and will probably amount to at least $50 000 ten years hence. At that time, on the basis of past growth, the Society should have 1 200 members.

There is, therefore, ground for believing that the Society will have the ability and opportunity to provide a permanent home in less than ten years.

OBLIGATIONS OF THE SOCIETY TO THE ENGINEERS CLUB.

Argument for Change.

While the Society is under no obligations to take quarters in the Engineers Club, it has through its Board of Government and by vote of the Society

given encouragement to the assumption that it would do so, and the Board of Governors of the Club have had this arrangement always in mind, thinking the Society would not do otherwise.

The club regards the occupation of quarters in its building by the Boston Society of Civil Engineers as something of mutual advantage to club and Society. If the Society does not see it in that light, the club will proceed with the plans for its building alterations and regard its own needs only.

Argument against Change.

The Society is under obligations to the club for its earnest endeavor to provide accommodations for the Society, by giving up room which is very desirable for club quarters.

Vote No. 2 mentioned in the report of the Board of Government states that " the Society desires quarters in such a building as is proposed," and this proposed building was large and contained spacious quarters for the Society, including the joint use of main auditorium and banquet hall 39 by 47 ft., with extensions of 26 by 38 ft. and 16 by 30 ft.; library 44 by 77 ft.; lounging room 30 by 44 ft.; Directors' room 24 by 24 ft.; and Secretary's office in addition. Such a vote does not involve any obligation in the very different case which is now presented.

GENERAL BENEFITS.

Argument for Change.

In the matter of the unification of the engineering interests in Boston it is freely conceded that the numerous local engineering and allied societies look to the Boston Society of Civil Engineers as a leader. If our Society should occupy a building with the Engineers Club, our present influence would be materially increased and would aid our members and those of the Engineers Club in attaining a broader view of engineering problems. The large and strong membership of the Engineers Club bids fair to become a power in our community. With a combination of these interests in the same building, strangers could enjoy the Society's excellent library facilities and the hospitality of the club with a minimum inconvenience. The dining facilities offered by the club to the members of our Society at the time of the regular meetings will create a social feature not existing before.

Argument against Change.

The suggestion that the change proposed would be likely to bring about coöperation and association with other technical bodies is answered by the statement that any extended coöperation and association is impracticable where the accommodations will not adequately provide for our own Society. The use of an assembly hall by different technical bodies on different nights is not coöperation or association. It is more probable that the change would cause the loss of the two technical bodies which now coöperate with our Society at the present quarters to the great advantage of the Society, and deter other technical bodies from coöperating with us in the future.

The Society is under obligations to its tenants for coöperation, which has not only been financially advantageous to the Society, but has resulted in better service at the rooms, one tenant having been continuously with the

Society for nineteen years, and it is an undesirable feature that the Society should take action in this matter without consultation with its tenants.

While the privileges of the club to non-members would be a source of pleasure to some members, the affiliation of the Society and the club in the way proposed is objectionable to other members of the Society.

The Society would lose prestige by locating as a sub-tenant in the back rooms of the club house.

If the letter ballot now sent out were to be decided in the affirmative, it would not provide for the use of the income of the Permanent Fund for paying the rent of the proposed quarters, because the by-laws provide that this income may be diverted only by a two-thirds' vote in favor at two successive meetings of the Society. If such two-thirds' vote were not obtained, the money would have to be raised by an increase in the dues or in some other way.

Summary of the Argument against Change.

The inadequacy of the proposed quarters is the most important feature, as it would tend to suppress the growth of the Society and its affiliation with other technical bodies. In addition there is the less convenient location, the much greater cost, the probable delay in obtaining a permanent home, the dissatisfaction of a portion of the membership with such affiliation and the loss of prestige by the Society from the acceptance of such an unsuitable home.

The above arguments for the proposed change were prepared by the first three members of the committee; the arguments against change, by the last three members.

CHARLES T. MAIN,
GEORGE A. KIMBALL,
HENRY F. BRYANT,
FREDERIC P. STEARNS,
C. FRANK ALLEN,
JOSEPH R. WORCESTER,
Committee.

WORCESTER, MASS., JUNE 6, 1912. — The annual June Excursion of the Sanitary Section of the Boston Society of Civil Engineers was held on this day at Worcester, Mass.

Through the courtesy of his Honor the Mayor and Superintendent of Sewers Mathew Gault, the Section was invited to inspect the Worcester Sewage Disposal Works at Quinsigamond as guests of the city.

The party assembled at the Worcester Union Station shortly after 1 o'clock P.M., having made the trip from Boston and other points by trolley and steam railroad.

A special electric car provided by the city was in waiting, and in it the party were conveyed to Greenwood Park, near the sewage disposal works, where an excellent buffet lunch was provided. There were 53 members and friends of the Sanitary Section present. The city of Worcester was officially represented by Alderman Harrop, chairman of the Sewer Committee.

After the lunch, the party gathered in a sheltered spot on the side hill of the park, and a photograph was taken. Chairman George C. Whipple spoke briefly in appreciation of the courtesy shown the Section by the city in extending the invitation and in providing the special car, buffet lunch and other

attentions which helped to make the trip so successful, and also of the efforts of Supt. Mathew Gault and his assistants to make the trip enjoyable. Mr. Gault gave a short history of the sewage disposal works and a description of the processes employed. The party then walked over to the works and were conducted about by Mr. Gault, Mr. Fales, supervising chemist, and Mr. Jones, assistant chemist. Although all of the features attracted much attention, the greatest interest was shown in the experimental work being carried on with an Imhoff tank and sprinkling filters. A quantity of sludge was drawn off from this tank, and opportunity was also given to examine sludge drawn the day before, and some drawn about two weeks previously. The sludge had a faint tarry odor, but was otherwise unobjectionable. There was certainly no trace of the characteristic sewage odor usually found in sludge from other processes. The mass appeared to be full of gas, and showed indications of drying quickly when run on to the sand bed.

The sludge tanks, presses, filter beds, laboratory and all the details were exhibited and explained in a most interesting manner.

It was after 5 o'clock when the party left the sewage disposal works and proceeded by special car to the Southbridge Street junction of the Boston & Albany Railroad and the New York, New Haven & Hartford Railroad. The most spectacular part of the grade crossing work which has been going on for some time is nearing completion at this point. Mr. Jameson, resident engineer for the work, conducted the party, and gave a great deal of interesting information in regard to the steel and concrete construction. A large variety of structures have been built to carry the railroads over the streets and crossings, and some of the steel work involved is of exceedingly heavy construction. This is especially true of the plate girders at Southbridge Street, designed to carry one railroad over the other.

From Southbridge Street the trip followed along the railroad back to the station. All of the structures were inspected, and many unusual features were examined. The thanks of the Section were extended to Mr. Jameson for his courtesy in explaining the work under his charge.

The majority of the party left Worcester on the 6.17 o'clock train, although some went by trolley and train at an earlier hour.

FRANK A. MARSTON,
Clerk.

Louisiana Engineering Society.

REGULAR MEETING OF THE SOCIETY, MAY 13, 1912. — The meeting was called to order at 8.30 P.M. by President Anderson, with 26 members and guests present.

The minutes of the meeting held April 8, 1912, were read and approved.

There being no reports of committees or other business, the technical exercises of the evening were held.

Mr. Chas. E. Snypp read a very interesting and instructive paper entitled, "Value of Saw-Mill Refuse as Fuel in Gas Producers." A general informal discussion followed from which a great deal of additional information was obtained.

There being nothing further before the meeting, the Society adjourned to a collation which had been prepared.

JAMES M. ROBERT, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XLIX. AUGUST, 1912. NO. 2.

PROCEEDINGS.

Utah Society of Engineers.

MINUTES of meeting held at the headquarters, 702 Newhouse Building, evening of June 21, 1912.

Meeting called to order by President Brown at 8.20 P.M. with 19 members and 3 visitors present.

An informal report was made by Professor Lyman, of the Entertainment Committee, suggesting a trip during the summer to the new "Strawberry" Tunnel in Spanish Fork Irrigation District.

Chairman Peters, of the Program Committee, outlined his ideas for the coming season.

On account of absence of Chairman Wilson, no report was made by Membership Committee.

The annual report of the outgoing Treasurer, A. S. Peters, was read and accepted, and the Executive Committee instructed to audit the books.

The annual report of the Secretary was not submitted on account of the absence of Prof. R. B. Ketchum.

New Business. — Mr. L. Wilson, for the Executive Committee, submitted the draft of a proposed revised Constitution for the consideration of the Society. Discussion and revisions as follows:

Motion by Mr. Sheley, and seconded, that age limit for "Juniors" be thirty instead of twenty-six years. Adopted.

Motion by Professor Beckstrand that Paragraph 1, Article 2, show "Honorary Members" first on the list. Seconded and after discussion was not carried.

Motion by Professor Beckstrand, and seconded, in Article 4, Paragraph 2, to change dues for "Associate Members" from $4 to $5 per year. Discussion by Professor Beckstrand, Professor Merrill, Mr. Wilson and Mr. Brown. Not carried, by rising vote: for, 3; against, 10.

Motion made by Mr. Peters that Paragraph 6, Article 3, be changed to so read that final approval of selection for "Honorary Members" be made by affirmative letter ballot of five sixths of the membership. Discussion by Mr. Brown, Mr. Peters, Mr. Harris, Mr. Wilson, Professor Lyman, Professor Beckstrand. Motion seconded but not carried.

Motion by Professor Merrill, and seconded, to change Line 2, Paragraph 6, Article 3, to read, " ten members other than the Executive Committee." Carried.

Discussion on " Application for Membership " requiring three members of the Society to vouch for applicant. This clause satisfactory to all present.

Discussion on Article 8, Paragraph 1, " Meetings to be held," by Mr. Harris, Mr. Wilson, Mr. Brown. Motion made and seconded that meetings be held the *third* week of the month. Carried. Mr. Wilson appointed by the chair as committee of one to ascertain and report later as to which night of the week would suit the majority of the members.

Motion by Mr. L. Wilson, and duly seconded, that formal notice be given that a " new constitution " would be submitted to the Society for adoption at the next regular meeting; carried unanimously. Copies of the draft as submitted by Executive Committee with amendments approved this evening to be posted at the following places, viz., University of Utah, University Club, Room 702 Newhouse Building, Salt Lake City, Utah; and Telluride Power Company, Provo, Utah.

The following names of new members approved by the Executive Committee were submitted, and under suspension of rules the Secretary was instructed to cast the vote of the society in their favor.

Mr. David Henry Blossom, city engineer, Salt Lake City; Mr. John Duder, assistant city engineer, Salt Lake City; Mr. Leopold Francis Zulick, office engineer, City Engineer's Office, Salt Lake City; Mr. Luther M. Windsor, assistant irrigation engineer, Utah Agricultural College, Logan, Utah.

Motion made and carried to adjourn.

On account of the late hour, Professor Lyman gave only a short talk, outlining his paper on " The Use of the Weir for the Measurement of the Flow of Streams," promising to give the complete paper at some future meeting.

FRED D. ULMER, *Acting Secretary.*

Association of Engineering Societies.

Vol. XLIX. SEPTEMBER, 1912. No. 3.

PROCEEDINGS.

Technical Society of the Pacific Coast.

San Francisco, August 9, 1912. — Regular meeting held in the Board Room of the Mechanics Institute.

The meeting was called to order at 8 P.M. by Past President Grunsky.

The minutes of the last regular meeting were read and approved.

Mr. G. Alexander Wright proposed for membership, on July 10, 1912, the name of Jasper S. Connell, engineering contractor, San Francisco.

The Board of Directors approved the application. Mr. Connell was duly elected a member of the Society, dating from August 1, 1912.

The Secretary brought up for general discussion a paper written by Mr. J. H. G. Wolf, on the " Regulation of Industries by Governmental Supervision," the subject-matter of which was discussed by Mr. Grunsky, Mr. Sanborn, Mr. Larkin and Mr. Schulze.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XLIX. OCTOBER, 1912. NO. 4.

PROCEEDINGS.

Engineers' Club of St. Louis.

THE 723d meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday evening, June 5, 1912, at 8.15 P.M., President Langsdorf presiding. There were 30 members and 22 visitors present.

Minutes of the 717th, 718th, 719th, 720th, 721st and 722d meetings of the Club were read and approved. The minutes of the 511th, 512th, 513th and 514th meetings of the Executive Committee were read.

Messrs. John Hornbrook and George R. Wadleigh were elected to membership.

The names of John F. Miller, John J. Clark and Walter H. Evans were proposed for membership, and William F. Silver for junior membership, and on motion of Mr. Metzger were referred to the Executive Committee for immediate consideration and report. The President declared a recess, during which the Executive Committee met; the meeting was again called to order and on recommendation of the committee a ballot was taken, resulting in the unanimous election of the four last-named gentlemen.

Mr. Von Maur moved that the President appoint a committee to recommend amendments to constitution and by-laws in order to revise the system for the election of members, and also to dispense with the reading of the Executive Committee reports in details, thus economizing the time of the meetings. The motion was seconded and carried.

The Librarian made a loose-leaf report in the matter of a loose-leaf catalogue, and stated that a new inventory of the library would be made during the summer and a detailed report submitted in the fall.

Mr. Rolfe moved that a committee representative of the Associated Engineering Societies of the City of St. Louis be appointed to investigate the subject of quarters and to report to the club on reassembling in the fall. Seconded and carried. The President announced the appointment of Messrs. Hunter, chairman; Flad, Toensfeldt, Greensfelder, Jewett and Schuyler.

Mr. A. Lee Moorshead, structural engineer for the Erie Railroad, presented a paper (illustrated) on the "Construction of the Four-Track Berger Hill Tunnel Line at Jersey City."

After discussion of the paper, the meeting adjourned to the library room, where refreshments were served.

Adjourned.

W. W. HORNER, *Secretary.*

Boston Society of Civil Engineers.

BOSTON, MASS., JUNE 20, 1912.—A regular meeting of the Boston Society of Civil Engineers was held at the Boston City Club, at 8.15 o'clock, President James W. Rollins in the chair, about 180 members and visitors present.

The reading of the record of the last meeting was by vote dispensed with.

The Secretary announced that the Board of Government had elected, as members of the Society, Messrs. Mark Linenthal and Richard Curtis Smith.

The report of the Committee of the Society appointed to prepare a code of ethics was presented and by vote ordered to be printed in the next *Monthly Bulletin* of the Society.

The President then introduced Col. George W. Goethals, chairman and chief engineer of the Isthmian Canal Commission. Colonel Goethals gave a most interesting account of the Panama Canal, reviewing carefully the history of the undertaking, and describing fully, but in a wonderfully concise manner, the stupendous work in which he is engaged. His talk was illustrated by a very large number of lantern slides. At its conclusion the President expressed the deep appreciation of the Society of the honor accorded it by the speaker of the evening, and extended to him the sincere thanks of its members.

The meeting was preceded by an informal reception and dinner, at which Colonel Goethals was the principal guest; about eighty members were present.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., SEPTEMBER 18, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 8 o'clock, President James W. Rollins in the chair; 75 members and visitors present.

By vote, the reading of the records of the May and June meetings was dispensed with and the records as printed in the *Bulletin* were approved.

On motion of Mr. Hodgdon, the report of the Committee on Code of Ethics, presented at the last meeting and printed in the September *Bulletin*, was accepted. After a discussion and several changes suggested in the phraseology of some of the articles in the proposed code, it was voted that the report be referred back to the committee to consider the suggestions which had been offered, and any others which may be submitted, and that it be requested to present the code in a revised form at the next meeting.

The President stated that he should rule that the adoption of a code of ethics substantially in the form already presented by the committee would not be subject to the provisions of the Constitution in reference to endorsement of propositions.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Richard Brunel, Herbert Winfield Dyer and Calvin Crosby Sears, and as a Junior, Henry Lowell Crocker.

The Secretary also announced the deaths of the following members of the Society:

George I. Leland, died May 16, 1912.
J. Edwin Jones, died June 3, 1912.
Robert Leland Read, died June 5, 1912.
Charles R. Cutter, died July 30, 1912.

By vote the President was requested to appoint committees to prepare memoirs. The President has constituted these committees as follows: On memoir of George I. Leland, Mr. William S. Johnson; on memoir of Robert L. Read, Mr. Desmond FitzGerald; on memoir of J. Edwin Jones, Messrs. F. L. Miner and E. D. Treadwell; and on memoir of Charles R. Cutter, Mr. Edgar S. Dorr.

The Secretary also reported that the Board of Government had appointed the following committee to recommend the award of the Desmond FitzGerald Medal for the best paper published by the Society during the year ending with the month of September, 1912: Messrs. J. R. Worcester, L. C. Wason and H. J. Hughes.

On motion of Professor Moore, the thanks of the Society were voted to the engineers of the Boston Transit Commission, and to the Hugh Nawn Construction Company, for courtesies extended to its members on the occasion of the visit to the Boylston Street Subway this afternoon.

The President called attention to the addition which had been made to Society quarters and to the necessity of providing new and additional furnishings for the rooms. The Board of Government had considered the matter and had voted unanimously to recommend to the Society that a sum not exceeding $1,200 be appropriated from the Permanent Fund of the Society, to be expended under the direction of the Board for furnishing and fitting up the Society's rooms.

After an explanation by the Secretary of the needs of the Society for additional furniture, book stacks, etc., Mr. Johnson moved that the recommendation of the Board of Government be adopted. Mr. Howe suggested that the sum needed be borrowed from the Permanent Fund, to be paid back from the Current Fund whenever possible, and he moved as an amendment: That the Board of Government be authorized to borrow the sum of $1,200 from the Permanent Fund, to be expended in furnishing and fitting up the rooms. On a vote being taken the amendment was lost.

Mr. Cowles moved to amend the recommendation by increasing the sum appropriated from $1,200 to $2,000, and on a vote being taken, the amendment was adopted, 23 in favor and 18 against.

The following vote was then adopted, 40 in favor and 4 opposed: *Voted:* That a sum not exceeding $2,000 be appropriated from the Permanent Fund of the Society, to be expended under the direction of the Board of Government for furnishing and fitting up the Society's rooms.

The President stated that under the Constitution it was necessary that an appropriation made from the Permanent Fund must be passed by a two-thirds vote at two successive regular meetings.

Mr. Clarence T. Fernald then read the paper of the evening entitled, "Notes on the Construction of the Charles River Bridge for the Boston Elevated Railway Company." The paper was illustrated by lantern slides.

After a short discussion, in which the President, Mr. G. A. Kimball, Mr. F. H. Fay and others took part, the meeting adjourned.

S. E. TINKHAM, *Secretary.*

Technical Society of the Pacific Coast.

San Francisco, September 13, 1912. — Regular meeting held on the evening of Friday, September 13, beginning at eight o'clock.

The meeting was called to order by Director Harry Larkin. The minutes of the last regular meeting of the Society were read and approved.

Past President C. E. Grunsky addressed the members on the subject of the " Relation of the Dimensions of Seagoing Vessels to the Dimensions of Maritime Canals and Prevailing Harbor Depths." Mr. Grunsky had this subject before the Twelfth International Navigation Congress, May 23–30, 1912, as general reporter of one of the sections. He explained at length the views of professional experts, who acted in the capacity of members of the section. The representation consisted of G. de Thierry, Baurat, Professor an der Kgl. Technischen Hochschule, Charlottenburg, Germany, and member of the Technical Commission of the Suez Canal; H. Van der Vin, Ingenieur en Chef, Directeur des Ponts et Chaussées, Antwerp, Belgium; Dr. Sc. E. L. Corthell, consulting civil engineer, New York; J. Foster King, chief surveyor to the British Corporation for the Registry of Shipping, Glasgow; E. I. Zamjatin, naval engineer, St. Petersburg, Russia.

Dr. Eng. Grunsky, as general reporter, stated that the following conclusions appear to be justified and that they were recommended for adoption by the Congress:

I. It is desirable that a limit be set to the draft of seagoing vessels.

II. Government aid should not be extended to the building or operation of seagoing vessels whose draft exceeds 9.5 meters (32.2 ft.).

III. There should be an international agreement fixing the maximum dimensions of seagoing vessels built or operated under government subvention, and there are tentatively suggested the following:

Length over all, 900 ft. (275 meters); breadth, 105 ft. (32 meters); draft, 32.2 ft. (9.5 meters).

IV. Any maritime canal which has locks with a usable length of 1 000 ft. (305 meters), a width of 110 ft. (33.6 meters) and a depth of water on the sill of 35 ft. (10.7 meters) will fulfill every reasonable requirement of commerce

V. In a maritime canal a wet section five times as large as the immersed. portion of the largest ship which is to use the canal is desirable, as also a depth of one meter under the keel; but these values are functions of the speed at which the canal is to be navigated and therefore to some extent also of the volume of commerce, and are to be determined by local conditions.

After a lengthy and interesting discussion of this important subject, the meeting adjourned.

Otto von Geldern, *Secretary.*

Association of Engineering Societies.

VOL. XLIX. NOVEMBER, 1912. NO. 5.

PROCEEDINGS.

Engineers' Club of St. Louis.

THE 725th meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, October 2, 1912, at 8.15 P.M., President Langsdorf presiding.

This was a joint meeting with the St. Louis Association of members of the A. S. C. E. Present, 55 members and 21 visitors.

Minutes of the 724th meeting of the Engineers' Club read and approved and report of 518th meeting was read.

Messrs. G. E. Pfisterer and S. H. Wallace were elected members.

It was moved by Mr. Woermann, seconded by Mr. Pfeifer, that the recommendation of the Executive Committee in regard to the Business Men's League Committee of one hundred, to consider certain proposed legislation giving home rule to St. Louis in the matter of the police, election and excise department be adopted; i. e., that the President and Secretary of the Club be authorized to attend meetings of that committee as delegates from the Club. After discussion, the motion was carried by a vote of 20 to 16.

Proposed amendments to Section 7 of the By-Laws, having been printed and mailed to the membership, were presented to the meeting. It was moved by Mr. Sweetser that the form of amendment printed second be adopted. Seconded, and amendment adopted. Section 7 of the By-Laws is amended to read as follows:

Section 7. ELECTION, TRANSFER AND REINSTATEMENT OF MEMBERS. — Candidates for admission to the Club, or for transfer from the grade of associate member to member, or from junior to member or associate member, shall be proposed by not less than two members or associate members. The proposal shall contain a statement signed by the candidate of his age, residence, qualifications for membership or transfer, and that he will conform to the requirements of the Club if elected. The proposal will be received by the Secretary and referred to the Executive Committee, and if, upon examination, they shall find the candidate eligible and worthy of membership or transfer, they shall order the name of the candidate, with a brief summary of his qualifications, to appear on the next regular printed notice of the Club which is sent to all members. If within the next thirty days after the mailing of said notice, no objections shall have been made to the candidate's election or transfer, the President shall declare the candidate to be duly elected. But if any member addresses to the Executive Committee a written objection to the election or transfer of the candidate, the Executive Committee shall carefully re-examine the case, and, if two members of the committee should vote to sustain the objections to the candidate, the candidate shall be rejected and shall not again be eligible to candidacy within twelve months of such rejection.

The remainder of the section to remain unchanged.

Mr. Carl Gayler presented a paper on the "Reinforced Concrete Column."

Mr. Gayler discussed the Considère formula for hooped columns as given by Marsh, and the adaptation of it given in the St. Louis Building Code, calling attention to the apparent irrationality of the term expressing the value of the hooping.

The discussion following was led by Messrs. Toensfeldt, Martin and Schuyler. In concluding, Mr. Toensfeldt moved that a committee of the Club be appointed to study and investigate reinforced column formulas in relation to the St. Louis Building Code, and to report back to the Club. This motion was carried, and the President appointed Messrs. Gayler, Toensfeldt and Martin as the committee.

The attention of the Club was called to the new lantern installed in the meeting room, and Mr. Rolfe demonstrated some of the features of the operation of it.

Adjourned 10.30.

W. W. HORNER, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., OCTOBER 14, 1912. — The Civil Engineers' Society of St. Paul convened for its first meeting after its summer vacation on October 14. Twenty-four members with a large number of visitors were present.

The occasion for so large a number of visitors present was a very entertaining as well as instructive lecture on the Panama Canal, illustrated with very complete lantern slides, by Hon. F. C. Stevens, Representative from Minnesota's Fourth Congressional District. Mr. Stevens, on account of his many visits to the Isthmus in connection with his duties as a member of the House Committee on Interstate and Foreign Commerce, was able to explain in detail the many points of interest brought out by the stereopticon views, and the audience dispersed about 9.30 o'clock, feeling well repaid for attendance.

After the lecture the members adjourned to the society rooms, where a business meeting was held. Mr. Claussen, for the committee appointed to draft proper resolutions upon the death of member Horace E. Horton, reported that this matter had been referred to a subcommittee consisting of Messrs. C. F. Loweth and W. W. Curtis, who would probably have suitable resolutions prepared in the near future.

A communication from Flavel Shurtleff, of Boston, secretary of the National Conference on City Planning, was read and referred to Mr. O. Claussen, city engineer of St. Paul, authorizing him to make any suggestions to the above-named conference that might seem to him proper.

Mr. O. Palmer, librarian, called the Society's attention to the fact that a card-index system had been added to the library during the summer vacation.

The Secretary was authorized to tender a vote of thanks on behalf of the Society to Messrs. G. H. Hazzard, interstate park commissioner, and S. Robinson, of the Minneapolis General Electric Company, for favors shown the Society on its recent visit to Taylors Falls; also to Mr. G. W. Rathjens, of St. Paul, superintendent for the Twin City Brick Company, for similar favors in connection with its visit to this company's plant.

On account of the very fine entertainment given earlier in the evening, the Secretary was instructed to tender a vote of thanks to Congressman Stevens for his very complete exposition of the situation at Panama.

Mr. W. E. King, for the Entertainment Committee, reported that the Society would probably be given an opportunity at its next meeting to listen to a paper on "Railway Valuation," by President Jurgensen.

Messrs. H. C. Palmer and T. M. Comfort, formerly of St. Paul and now of Regina, Saskatchewan, having some time since signified their desire to resign from the Society, their resignations were accepted at this time.

Balloting for members then followed.

The names of C. Herschel Koyl, consulting expert for the Great Northern Railway; J. L. Pickles, chief engineer for the Duluth-Winnipeg and Pacific Railway; H. H. Burgess, engineer for Butler Brothers Company, of St. Paul; R. L. Smith, engineer for the St. Paul City Water Department; L. W. Clarke, city engineer of Stillwater; and H. W. Ker, St. Paul representative of R. H. Hyland & Company Railroad Supply House, were proposed for membership, and that of R. H. Milne, assistant in the office of the city engineer of St. Paul, for junior membership. The Secretary was instructed to cast the ballot of the Society for these gentlemen admitting them to membership.

This completed the business transacted at this time, and adjournment was accordingly taken at 10.00 P.M.

L. S. POMEROY, *Secretary.*

Montana Society of Engineers.

BUTTE, MONT., SEPTEMBER 14, 1912. — The meeting of the Society was held in its new quarters in the Silver Bow County Court House, at 8 P.M., President McArthur presiding. The members present were Bowman, Dunshee, McArthur, Moore, Sales and Simons. The minutes of the last meeting were approved as read. The Secretary read the applications for membership in the Society of Messrs. J. F. Daoust and A. W. Richter. Said applications were approved and ballots ordered. The report of the Committee on Badges was presented and the committee discharged. A cordial approval was given the Committee on New Quarters for the success of their labors. The Committee on Stream Measurements and Gaging was given further time in which to report. W. L. Miller's name was voted on corresponding membership list. Considerable discussion was had concerning the work of the Society in the way of papers, talks, etc., for the coming months, when adjournment followed.

CLINTON H. MOORE, *Secretary.*

Technical Society of the Pacific Coast.

REGULAR meeting held on Friday evening, October 11, at 8 o'clock, in the rooms of the Mechanics Institute, San Francisco; called to order by Mr. Harry Larkin.

The minutes of the last regular meeting were read by the Secretary. Mr. Grunsky stated that the recommendations made by the Section on Ships

and Maritime Canals, to the Twelfth International Navigation Congress, were not approved.

The minutes were amended to that effect.

Mr. B. J. S. Cahill addressed the members on the subject of "A New Projection for Depicting the Areas of the World on a Plane Surface."

While the Mercator projection and the gnomonic projection are extremely valuable as ocean charts to facilitate the determination of relative azimuths from one point of the earth to another, they are but scientific artifices, in which the continents become so distorted that it is utterly impossible to obtain any idea of their relative shapes and comparative areas; other projections are used that do show relations of size, but they suffer from some other distortion. The globe, therefore, has always been the only aid to show the actual and existing relations of land and sea.

Mr. Cahill explained a projection which he has developed, in which the land areas of the world are shown contiguously, in their proper size and location, made by slicing off four gores from the sphere, connected to each other at latitude 45 degrees, and spreading them like the wings of a butterfly.

This interesting lecture was listened to with great interest, and the subject was discussed at length by those present.

The meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

Louisiana Engineering Society.

REGULAR MEETING OF THE SOCIETY, OCTOBER 14, 1912. — The meeting was called to order with President Anderson in the chair and thirty-seven members and guests present. The minutes of the last meeting were read and approved.

The report of the committee appointed to pass resolutions on Major Harrod's death was read and adopted.

The report of the Outing Committee was read and on motion of Mr. Coleman was approved, and the recommendations made in the report ordered carried out by a committee to be appointed by the President.

The President made several announcements, after which the technical exercises of the evening were in order.

Mr. Ole K. Olsen was introduced and read a very instructive and entertaining paper entitled, "The Diesel Engine as Motive Power in the Merchant Marine with Special Reference to the First Successful Motor Ship *Christian X*."

After the exercises were finished, Mr. Olsen was extended a rising vote of thanks.

There being no further business, the meeting adjourned to the usual collation.

Oregon Society of Engineers.

THE June meeting of the Society took the form of a dinner, instead of the regular meeting of the Society on the second Thursday of the month, and about sixty members were present at six o'clock in the Elizabethan Room of the Imperial Hotel on Wednesday, June 19, 1912; the notice calling the meeting

stating that after this dinner the meetings would be intermitted until September 12.

Vice-President W. S. Turner presided, and the minutes of the previous meeting were read and approved.

The speaker of the evening was Mr. Edward Cookingham, who chose for his subject "The Need of Reform in Our Monetary System." Keen attention was paid to the speaker, and a lively discussion of the subject followed the close of his remarks.

After dinner the competitive drawings for a society emblem were exhibited and inspected and discussed. Much originality was displayed in the exhibit, some of the designs being unique; but it was the general opinion that a design more emblematic of the general character of the Society than any so far submitted should be adopted, and the members of the Executive Board were authorized to call for additional designs and to exercise their judgment in the choice of a design to be finally adopted.

Representatives from the *Evening Telegram*, *The Journal* and *Pacific Builder and Engineer* were present as guests of the Society.

A vote of thanks was tendered to Mr. Cookingham, and the meeting adjourned.

F. A. Naramore, *Secretary.*

Executive Board Meetings.

Portland, Ore., July 15, 1912. — Meeting called to order by President D. C. Henny.

The death of Mr. C. B. Smith left a vacancy in the office of second vice-president and in the Executive Board. Mr. Ralph Budd, a member of the board, was elected to fill the vacancy in the office of second vice-president; and Mr. H. L. Vorse was elected as a member of the board, to serve for the unexpired term of Mr. Budd.

The Secretary was directed to send a letter to Mrs. Smith, conveying to her the sympathy of the Executive Board and the great regret of the Society over the loss of Mr. Smith as vice-president and member of the Society.

Adjourned.

F. A. Naramore, *Secretary.*

Portland, Ore., September 9, 1912. — Special meeting, called to order by President D. C. Henny.

It was ordered that a letter be sent to each member of the city council, objecting to and protesting against the granting of special permits for the construction of buildings in violation of the Building Code of the city of Portland.

Adjourned.

F. A. Naramore, *Secretary.*

Portland, Ore., September 19, 1912. — Meeting called to order by Vice-President Wm. S. Turner. Minutes read and approved.

Paul S. Schuchart was elected chairman of Membership Committee.

After discussion, it was decided that the policy of allowing members to be

in arrears for dues for one year shall be followed, instead of six months, as provided by the constitution.

Adjourned.

F. A. Naramore, *Secretary.*

Portland, Ore., October 4, 1912. — Special meeting, called to order by Vice-President Wm. S. Turner. Minutes read and approved.

F. A. Naramore was named as a member of the Tuesday noon luncheon committee, to represent the Oregon Society of Engineers.

Moved, seconded and carried, that the Oregon Society of Engineers join with the Local Section American Society of Civil Engineers, Portland Section American Institute of Electrical Engineers, Oregon Chapter American Institute of Architects, Local Section National Electric Light Association, and Portland Architectural Club, for the purpose of securing joint quarters, and that the coöperative committee be empowered to negotiate for the same, for a period of one year, expenditure for the same not to exceed forty-five dollars per month.

Meeting adjourned.

F. A. Naramore, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XLIX. **DECEMBER, 1912.** NO. 6.

PROCEEDINGS.

Engineers' Club of St. Louis.

THE 726th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, Wednesday, October 16, 1912, at 8 P.M., President Langsdorf presiding.

This was an open meeting, and, of the 130 present, 40 were ladies.

The minutes of the 725th meeting were read and approved.

Col. John A. Ockerson then delivered an interesting and informal address, illustrated with lantern slides, on "The Colorado River Delta and the Salton Sea."

After discussion of the remarks, the meeting adjourned to the library, where elaborate refeshments were enjoyed.

W. W. HORNER, *Secretary.*

THE 727th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Olive Street, on Wednesday, November 6, 1912, at 8.30 P.M. There were present 29 members and 17 visitors.

This was a joint meeting with the St. Louis Section, A. I. E. E. Messrs. W. E. Rolfe, M. Schuyler, E. D. Smith, E. E. Wall and J. D. Von Maur were elected as the Nominating Committee of the club for 1913.

Mr. Schuyler, chairman of the Entertainment Committee, asked for suggestions as to the character of the next annual banquet. After discussion, Mr. Rolfe moved that the annual dinner be informal and cost not over $1.50 per plate. Seconded and carried.

All other business having been suspended, President Langsdorf resigned the chair to Chairman Osborn of the St. Louis Section, A. I. E. E.

Mr. F. A. Barker, safety engineer for the Committee on Accident Prevention and Workmen's Compensation, of the National Manufacturers Association, read a paper on "Accident Prevention," after which he exhibited a great number of colored slides showing guards for various machines and a motion picture specially arranged for his committee.

Adjourned at 10.15 P.M.

W. W. HORNER, *Secretary.*

Civil Engineers' Society of St. Paul.

St. Paul, Minn., November 11, 1912. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held in the Society's rooms in the Old Capitol, Monday evening, November 11, President D. F. Jurgensen presiding. There were present 15 members and 6 visitors.

After the approval of the minutes of the October meeting, W. E. King reported on behalf of the Entertainment Committee that negotiations were being made with Mr. Walter Buehler, of Minneapolis, representing the Kettle River Quarries Company, for an illustrated lecture on the general subject of Creosoting.

O. Claussen reported for the Horton Memorial Committee that resolutions upon the death of member H. E. Horton had been prepared by Mr. Curtis of this committee, and were in process of ratification by them.

A query by the Secretary in regard to the eligibility of mechanical engineers for membership in the Society elicited considerable discussion, which resulted in a motion by W. E. King that a committee be appointed to ascertain the reasons for the term "mechanical engineer" having been dropped from Article 3 of the Society's constitution, and if found necessary such committee to draft an amendment reinserting same. Motion was made by J. H. Armstrong to amend Mr. King's motion by restricting power of said committee to making a report of its findings to the Society, the subject of amending Article 3 of the constitution to be taken up later; carried as amended. Messrs. Annan, Palmer and Pomeroy were subsequently appointed.

A suggestion was offered by the President that it might be well to organize a branch society in which signal engineers would be eligible to membership, as there were a number of such engineers connected with the various railroads terminating in the Twin Cities, and such a branch society would tend to the mutual benefit of these and the Society's present membership. This suggestion elicited some discussion *pro* and *con*, but no action was taken, — the Society deciding individual consideration by its members until a later date should precede such action.

Balloting for members then followed; the names of C. N. Kalk, of Minneapolis, chief engineer of the Minneapolis, St. Paul & Sault Ste. Marie Railway, and W. F. Rosenwald, of Red Wing, division engineer for the Minnesota State Highway Commission, were proposed for membership. Upon motion of Mr. O. Palmer, the Secretary was instructed to cast the ballot of the Society admitting these to membership.

A paper on Railway Valuation, entitled, "Reproduction Cost New as a Sole Basis for Rates," was then read by President D. F. Jurgensen. Discussion of this paper at its close was participated in by a great many of those present, notably by Messrs. Toltz, Claussen, Simons, Pomeroy, Herrold and Brink, after which adjournment was taken at about 10 P.M., a very profitable evening having been spent.

L. S. Pomeroy, *Secretary.*

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DECEMBER, 1912.

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